

PHARMACEUTICAL MATERIALS AND  
METHODS FOR THEIR PREPARATION AND USE

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BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to pharmaceutical formulations involving the inclusion of an active pharmaceutical ingredient ("API") in a pharmaceutically-acceptable single crystal matrix. More particularly, the crystals contain growth-sector specific, oriented inclusions of active pharmaceutical ingredients which are isolated. The active pharmaceutical ingredients have higher stability and shelf-life, and can be delivered in conventional dosage forms. This invention has general application to active pharmaceutical ingredients, and in one aspect has particular application to biopharmaceuticals. As used herein, the term "biopharmaceuticals"

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is used to refer to a subset of API's which are polymeric in nature, including for example, proteins, polypeptides, enzymes, immunoglobulins, polynucleic acids, and plasmids.

Description of the Prior Art:

There is a continuing need for pharmaceutical compositions which are capable of maintaining the quality and efficacy of the API during storage and delivery. The loss of potency of an API is a critical concern in assuring that viable, effective drugs are delivered to patients. It is similarly desirable to have formulations which do not require special packaging or handling. Further, it remains a constant goal to provide active pharmaceutical ingredients in a form

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which facilitates their use by the consumer, such as through convenient dosage forms. The present invention addresses these and other issues concerning pharmaceutical compositions and formulations.

Although not limited to biopharmaceuticals, the usefulness of the present invention is well exemplified with respect to biopharmaceuticals, many of which demonstrate the problems encountered in prior-art approaches. Ensuring long-term stability and maintaining activity of biopharmaceuticals is a prevalent concern.

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The chemical complexity and conformational fragility of protein drugs, for example, make them highly susceptible to both physical and chemical instabilities

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and threaten their emergence into the marketplace. Denaturation, adsorption with container walls, aggregation, and precipitation can result from non-covalent interactions between a drug and its environment. Insulin, for instance, has been shown to adsorb onto the surfaces of glass and plastic containers, and to have  
5 interactions at air-water interfaces, leading to denaturation, aggregation and precipitation. For example, upon denaturation human growth hormone (HGH) forms dimers and higher molecular weight aggregates, and glucagon in solution has been shown to readily gel or aggregate when subjected to mechanical stress.

As a further example, researchers have distinguished nine major reaction  
10 mechanisms by which proteins degrade, including hydrolysis, imide formation, deamidation, isomerization, racemization, diketopiperazine formation, oxidation, disulfide exchange, and photodecomposition. The rates of these deleterious processes depend in large measure on the protein and its environment. The primary chemical degradation products of glucagon, for example, include  
15 oxidation of Met (27), deamidation of Gln (24), and acid-catalyzed hydrolysis at Asp (9), Asp (15) and Asp (21). HGH undergoes chemical decomposition via oxidation at Met (14) and deamidation at Asn (149).

A critical challenge of product development science in the pharmaceutical industry therefore has been devising formulations that maintain the stability of the  
20 active pharmaceutical ingredient over an acceptable shelf-life. This has been especially difficult to achieve for certain API's which are unstable in solution or with respect to many common formulation processes. Developing techniques for stabilization and storage looms as a great impediment to the pharmaceutical industry. Formulation scientists have consequently used a variety of techniques to  
25 enhance the stability of API's while maintaining other important product characteristics such as biocompatibility, absorption, pharmacokinetics, efficacy and excretion.

One technique used in formulating biopharmaceuticals has been lyophilization of the biopharmaceutical solution in the presence of excipients,  
30 buffers and/or bulking agents. However, even lyophilized preparations must typically be stored under refrigeration, a requirement which is neither technically

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nor economically feasible in many markets and inhibits flexibility of patient use. There has therefore been a continuing demand for formulations of many biopharmaceuticals which would permit their storage at ambient temperatures. This would permit more rapid development of products, increasing flexibility in shipping, storing and carrying the drug products, and allowing introduction and use of such products in markets where refrigeration is too costly. Moreover, the increased stabilization of biopharmaceuticals would naturally improve the general use of the biopharmaceuticals where shelf life is an important consideration, whether or not refrigeration or other concerns are at issue.

The prior art use of excipients in the lyophilization of biopharmaceuticals has been directed away from inclusion of the biopharmaceuticals in single crystals in the manner of the present invention. It has been widely assumed that amorphous glasses are critical in the stabilization of biopharmaceuticals by such excipients in lyophilized form, and it has been suggested that the drug molecules must exist in amorphous regions between the crystalline domains. See, e.g., M. J. Pikal, "Freeze Drying of Proteins", to be published in Peptide and Protein Delivery, 2<sup>nd</sup> Ed., V. H. L. Lee, Marcel Dekker, Preprint, 1995. Implicit in this reasoning is the conclusion that the biopharmaceuticals could not exist as guests within single crystals.

In the process of lyophilization, typically an aqueous solution containing a biopharmaceutical with a limited amount of excipient(s) is frozen and then dried under vacuum to produce solids of sufficient stability for storage and distribution. Excipients are added to prevent blow out of the product, to provide stability during lyophilization and/or dissolution, and to enhance compatibility for parenteral use. Various excipients used with lyophilization have included salts, metal ions, polyalcohols, surfactants, reducing agents, chelating agents, other proteins, amino acids, fatty acids, and phospholipids. The more frequently used excipients include mannitol, alanine, glycine, sorbitol, lactose, arginine, and maltose. The results obtained with such excipients, however, have usually been inconsistent. Most lyophilized biopharmaceuticals are amorphous powders that have no specific structure, and as a result, the amount and location of the incorporated biopharmaceutical varies widely for the product particles. Also, they are typically

readily dissolved, rendering them unsuitable for use as a sustained-release material.

Further, there is no isolation of the pharmaceutical molecules from the environment or one another, leaving them susceptible to degradation by various mechanisms. Studies have shown that lyophilization of excipients can typically damage proteins rather than protect them. See, e.g., J. F. Carpenter, J. H. Crowe, "Infrared spectroscopic studies of the interaction of carbohydrates with dried proteins", *Biochemistry* 1989, 28, 3916-3922; J. F. Carpenter, S. Prestrelski, T. Arakawa, "Separation of freezing- and drying-induced denaturation of lyophilized proteins by stress-specific stabilization: I. Enzyme activity and calorimetric studies," *Arch. Biochem. Biophys.* 1993, 303, 456-464. K. Izutsu, S. Yoshioka, Y. Takeda, "The effects of additives on the stability of freeze-dried  $\beta$ -galactosidase stored at elevated temperatures", *Int. J. Pharm.* 1991, 71, 137-146. K. Izutsu, S. Yoshioka, T. Teroa, "Decreased protein-stabilizing effects of cryoprotectants due to crystallization", *Pharm. Res.* 1993, 10, 1232-1237.

Crystallized pharmaceuticals have been used in some instances, but there have been inherent limitations. Some API's, e.g. insulin, can be crystallized themselves, and are useful in that form for administration to patients. However, the majority of biopharmaceuticals either do not crystallize or the crystallization is very difficult, particularly on a commercial scale. Further, crystallization procedures are limited to the use of pharmaceutically-acceptable ingredients and process conditions that do not adversely affect the active pharmaceutical ingredient, thus further constraining the ability to obtain desired microcrystalline suspensions.

The fact that macromolecules are routinely isolated in sub-millimolar concentrations in a variety of crystals is known. See, e.g., K. Strupat, M. Karas, F. Hillenkamp, *Int. J. Mass Spec. Ion Proc.*, 111, 89-102, 1991. Also, certain aromatic acids have been employed as hosts for biopolymer guests in crystals for use in matrix-assisted laser desorption ionization (MALDI) mass spectrometry, but not for the purposes of the present invention. See, Review by F. Hillenkamp, M. Karas, R.C. Beavis, B.T. Chait, *Anal. Chem.*, 63, 1193A-1203A; S. Borman, *Chem. Eng. News*, 23-25, June 19, 1995. However, crystallization conditions in

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these studies were optimized for characterization of the incorporated biopolymers. There were no investigations into optimizations that would be relevant to pharmaceutical preparations or operations such as homogeneity of the concentration of the inclusions, process scale-up, process robustness, chemical and physical stability of the preparations, suspendability in biocompatible solutions, preservative requirements and compatibility, container/closure system compatibility, and pharmacokinetic profiles.

The difficulty in obtaining suitable single crystals of some biopolymers has encouraged structural chemists to partially orient such molecules with electric, magnetic, or flow fields, by dissolution in liquid crystals or stretched gels, and as monolayers. In a similar effort, the isolation of biopolymers in a single crystal matrix has recently been studied in an effort to use such crystals for structural analysis of the biopolymers. Such isolation technique is described in "Single Crystal Matrix Isolation of Biopolymers," J. Chmielewski, J.J. Lewis, S. Lovell, R. Zutshi, P. Savickas, C.A. Mitchell, J.A. Subramony, and B. Kahr, J. Am. Chem. Soc. 1997, 119, 10565-10566. However, this article simply demonstrates that certain biopolymers are oriented by the host lattice, and the article suggests the use of such crystals for analyzing spectral anisotropies in biological molecules which could not otherwise be crystallized. This article does not discuss or suggest the use of this technique for enhancement of stability or sustained release of pharmaceuticals, or their administration to patients. Further, the proteins studied were not of pharmaceutical interest, the crystal materials described in this article, namely phthalic acid, gentisic acid and sinapic acid, were not selected or evaluated for biocompatibility, and the crystal sizes were not optimized for particular routes of administration. Therefore, the produced crystals with included biopolymers would not be suitable for administration to patients.

Other prior art procedures have required the use of polymers that are difficult to prepare, require harsh preparation conditions that can be harmful to the API's, and yield inconsistent results. For example, United States Patent No. 5,075,291 describes a process for preparing a uniformly-dispersed, pharmaceutically-active material in a crystalline sugar alcohol matrix. However,

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this process requires the addition of the API into a molten sugar alcohol with considerable mechanical agitation. Many API's and virtually all biopharmaceuticals would not be stable in the extreme temperature of 110°C and the physical stresses of a high-shear vortex mixer used for agitation. The present invention does not require these extremes of temperature and physical agitation. Also, the process of the present invention slowly includes the API into the growing crystal lattice in specific growth sectors, instead of homogeneous mixing and entrapping of the active pharmaceutical ingredient in a viscous melt.

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### SUMMARY OF THE INVENTION

In one aspect, the present invention relates to pharmaceutical compositions comprising single crystals of a pharmaceutically-acceptable crystal lattice component, and an active pharmaceutical ingredient different from and included within the crystal lattice component in a growth-sector specific orientation. The crystals are prepared using components and methods which yield crystals having suitable purity and efficacy for use in administering the API's to a patient. The crystals may be coated or combined with adjuvants such as excipients, diluents or carriers, and are preferably formulated into tablets, capsules, suspensions, and other conventional forms containing dosage amounts of the API's. Alternatively, the crystals are prepared as depot formulations which may be administered, as by subcutaneous injection or implantation, to provide a long-term payout or sustained release of the active pharmaceutical ingredient. The present invention further provides methods for preparing the crystals and for storing and administering the active pharmaceutical ingredient either in crystal form or upon reconstitution to a solution.

Accordingly, it is an object of the present invention to provide single crystals which include API's in a growth-sector specific orientation. It is a feature of the invention that the API's are included at predictable, uniform concentrations that permit use of the crystals in formulating dosage amounts of the API's.

Another object of the present invention is to provide compositions comprising API's included in single crystals to provide improved stability and shelf-life. The active pharmaceutical ingredients may therefore be stored for extended periods of time prior to use either as crystals or as reconstituted solutions.

It is a further object of the present invention to provide single crystals with included API's to provide quick, delayed-release or sustained-release formulations for flexibility in pharmacokinetic profiles in delivery of the API's to patients.

Another object of the present invention is to provide pharmaceutical delivery units including an amount of single crystals sufficient to provide a dosage amount of the included active pharmaceutical ingredient. Alternatively, the pharmaceutical delivery units include a quantity of crystals sufficient to provide a

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prolonged payout of the active pharmaceutical ingredient. The crystals may be coated or uncoated, and may be combined with various pharmaceutical adjuvants including excipients, diluents and carriers.

A further object of the present invention is to provide methods for  
5 preparing compositions comprising single crystals with growth-sector specific inclusions of API's.

It is another object of the present invention to provide methods for the storage and administration of API's utilizing inclusion of the API's within single crystals.

10 Other objects, features, and advantages of the present invention will be apparent to those skilled in the art from the following description and claims.

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### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a photomicrograph illustrating fluorescence of a single crystal of green fluorescent protein in  $\alpha$ -lactose monohydrate (1.8 (h) x 0.8 (w) x 0.5 (d) mm<sup>3</sup>) with an idealized representation of habit. The sides of the crystal in the  
5 photomicrograph are bright due to internal reflection.

Figure 2 is a graph of the fluorescence decay of the green fluorescent protein at 333°K in several environments: mixed crystal in  $\alpha$ -lactose monohydrate (triangle), saturated lactose solution (square), and lyophilized  $\alpha$ -lactose monohydrate (diamond).

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### DESCRIPTION OF THE PREFERRED EMBODIMENT

For the purposes of promoting an understanding of the present invention, reference will now be made to the embodiments described hereafter. It will nevertheless be understood that no limitation of the scope of the invention is  
5 thereby intended, such modifications and applications of the principles of the invention as described herein being contemplated as would normally occur to one skilled in the art to which the invention relates.

The present invention utilizes single-crystal matrix inclusion of active pharmaceutical ingredients ("API's") to achieve advantageous storage and delivery  
10 of the API's. This invention has application to a wide range of API's to provide enhanced stability and/or delivery of the active pharmaceutical ingredients. For some applications, such as for many biopharmaceuticals, the invention is particularly advantageous in providing greater stability over time and in providing alternative delivery and sustained release formulations to patients .

15 The small molecule host crystals comprise a crystal lattice component which includes the API's in an oriented, growth-sector specific manner. The crystals and included API's are prepared to be pharmaceutically acceptable and pure, thereby being useful for administration to patients to be treated with the API's. As used herein, the term "pharmaceutically-acceptable" refers to sufficient  
20 quality to meet regulatory and compendial requirements for administration to humans and/or animals. The crystals provide a regular, predictable inclusion of the guest active pharmaceutical ingredient, and the crystals can consequently be used for obtaining a predetermined amount of the active pharmaceutical ingredient for delivery to a patient. In one aspect, the host crystal gradually dissolves upon  
25 contact with body tissue or fluids, and is therefore useful as a system for delivery of the active pharmaceutical ingredient into the body. Alternatively, the crystals and included active pharmaceutical ingredient may be reconstituted into a solution for administration to a patient.

The active pharmaceutical ingredient molecules are generally isolated from  
30 one another and are insulated from the environment by the host crystal. This leads to reduced susceptibility of the API to degradation, and therefore enhanced

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stability and shelf-life. Also, the use of appropriate host crystal compounds, or selected dosage forms, permits the design of quick, delayed, or sustained-release formulations for delivery of the active pharmaceutical ingredient. Sustained-release formulations are particularly advantageous for treatment of chronic  
5 conditions as they provide a consistent amount of drug delivery over a long period of time to improve ease of use and patient compliance in administering the API.

The crystals preferentially incorporate the active pharmaceutical ingredient on certain faces, thereby providing a growth-sector specific inclusion and orientation to the API's. As used herein, the term "growth-sector specific  
10 inclusion and orientation," and equivalent terminology, refers to the fact that the API molecules are included primarily at certain faces of the crystal matrix. The growth-sector specific inclusion and orientation can be determined by one skilled in the art, as demonstrated in the examples herein, by fluorescence microscopy and anisotropy measurements, single crystal desorption mass spectrometry, and  
15 autoradiography of  $^{14}\text{C}$ -labeled material. In one embodiment, at least about 0.001% (on weight/weight (w/w) basis) of the pharmaceutical is included within specific faces of the crystal matrix, and in another embodiment at least about 0.1% (w/w) and up to about 10%. The crystal parameters, including the particular crystal lattice component for a given API, the concentration of API, the use of  
20 crystal adjuvants, and the crystallization conditions, are selected to achieve the growth-sector specific inclusion and orientation of the API within the crystals.

The method of the present invention broadly involves the including of the active pharmaceutical ingredient into the single crystal matrix formed from a pharmaceutically-acceptable crystal lattice component. As used herein, the term  
25 "included" in the crystals refers to the active pharmaceutical ingredient being chemically adsorbed within the crystal lattice as the crystal is formed. This inclusion of the active pharmaceutical ingredient molecules is distinguished from crystallization of the API molecules with one another, and from simple and random entrapment of the API molecules by the formed crystal. The crystal product of the  
30 present invention is ordered, in contrast to the amorphous material produced by other approaches. The API is incorporated in the crystal in relation to its degree of

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affinity for the crystal lattice molecules. The crystal lattice component is therefore selected to be both chemically and physically compatible with the API such that the API is received by the crystal during formation, and remains stable and efficacious while within the crystal and upon release therefrom.

5 In a typical approach, the including of the active pharmaceutical ingredient involves combining the crystal lattice component, the active pharmaceutical ingredient and a pharmaceutically-acceptable adjuvant in a liquid state. The crystal lattice component is then crystallized under pharmaceutically-acceptable conditions to form the inventive crystals. For example, one method uses spiking of  
10 the API into a saturated or supersaturated solution of the crystal lattice component in a suitable organic and/or aqueous solvent system. Alternately, the saturated or supersaturated solution of the crystal lattice component may be spiked into the API solution. Other components may also be added to the solution, including compounds which facilitate or modify crystal growth or which are desired for  
15 incorporation in the final formulation. The solution may be seeded using any of a variety of conventional techniques.

In one approach, the solution is allowed to evaporate and/or equilibrate to cooler conditions for growth of the crystals. The crystals are then grown as the solvent is slowly evaporated away and/or the solution is cooled, with the  
20 evaporation and temperature gradient conditions being selected dependent on such factors as the solvent system and the desired crystal size. The crystals containing the active pharmaceutical ingredient are harvested from the remaining solution and are preferably washed to remove surface contamination. This procedure yields  
25 crystals which include the active pharmaceutical ingredient at a predictable concentration and facial orientation.

In accordance with the present invention, crystals are grown under pharmaceutically-acceptable conditions. As used herein, the term "pharmaceutically-acceptable conditions" refers to the use of crystal and API compounds which are pharmaceutically-pure, and for which such pharmaceutical  
30 purity is maintained in the final crystals. The crystal and API compounds are pharmaceutically pure, or have pharmaceutical purity, if they are of sufficient

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5     purity to be suitable for administration under applicable FDA or other administrative regulations regarding purity. The term pharmaceutically-acceptable conditions further refers to the use of crystallization conditions through which the API compounds retain pharmaceutical efficacy in the final crystals and upon subsequent administration to patients.

10     The present invention readily allows the inclusion of API's by affinity with the small host molecules in the growing crystal lattice. This overcomes many of the limitations associated with previous approaches. The processing involved with preparing the present crystals does not expose the API's to harsh conditions, thereby substantially reducing or avoiding the possible degradation or disruption of the structural aspects of the API which could occur with prior art techniques. The inventive crystals have an added advantage in that they do not interfere with normal analytical methodologies used for characterizing the pharmaceutical product. The small host molecules can be easily separated on the basis of

15     molecular size, which is not the case for prior art techniques which use polymers that interfere with analytical methodologies.

20     The API molecules are incorporated into the host crystals typically at rates of at least about 0.001% (w/w), preferably at least about 0.1%, and more preferably about 1% to about 10% (w/w). Alternatively, the API molecules are included at rates of at least about 0.01%, and as much as at least about 1% (w/w). The limited molar concentration of the active pharmaceutical ingredient in the host crystals means that the active pharmaceutical ingredient molecules are generally isolated from one another in the crystals. Isolation of the API molecules is particularly advantageous for those molecules, such as certain biopharmaceuticals, which could

25     otherwise react with one another (e.g., by polymerization) or the surrounding environment. The degree of isolation can be verified by those skilled in the art using atomic force microscopy or reaction fluorescence energy techniques. The present invention has a particular application to guest-host systems in which the guest API molecules are reactive with one another, but in which these molecules

30     are sufficiently isolated from one another in the crystals as to substantially prevent such interaction. Consequently, the invention provides containment of the API

molecules in the solid state crystals and provides for the API to be conformationally stable.

The method preferably involves preparing a mixture of crystals of substantially uniform size. This may include processing of the harvested crystals, such as by grinding or milling, to reduce the crystals to a substantially uniform size. Greater uniformity can be achieved by sorting the processed crystals, such as by sieving. A preferred method further includes obtaining crystals which have a substantially uniform concentration of pharmaceuticals, for example, about 1% (w/w) of pharmaceuticals, that do not vary between crystals by more than 10 percent.

The method of the present invention may further include formulating the crystals into pharmaceutical preparations. For example, the collected crystals may optionally be coated with a suitable composition. Coated or uncoated crystals may be blended with one or more pharmaceutically-acceptable adjuvants, such as excipients, diluents, carriers or mixtures thereof. The blended crystals and adjuvant(s) are then formulated into pharmaceutical delivery units. In one embodiment, each unit includes a predetermined amount of the pharmaceutical. Alternatively, the crystals are combined in a delivery unit intended to deliver multiple or sustained dosing of the API over a period of time, such as by subcutaneous implantation of the delivery unit. A further aspect of the method of the present invention involves reconstituting the crystals to liquid form. In accordance with this method, the harvested crystals are dissolved in a suitable diluent for the crystal lattice component. The dissolution of the crystals releases the API from the crystals. The resulting solution may include other adjuvants, such as excipients, diluents or carriers, and the mixture is formulated under conventional procedures to desired delivery forms. In a particular aspect of the present invention, the crystals are used to store the pharmaceutical for a period of time, such as at least one month, or at least one year, and the crystals are subsequently dissolved to use the active pharmaceutical ingredient.

The present invention involves the use of any of a wide variety of pharmaceutically-acceptable host crystal systems that can incorporate API's in a

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growing crystal lattice. The crystal lattice component is selected to be compatible with the guest API, and to be suited to the use of the resulting formulation for storage and administration. Selection of the crystal lattice component will involve consideration of such factors as affinity for the API, crystal size distribution and morphology, and desired pharmaceutical concentration and delivery rate, as well as other factors well known in the art of pharmaceutical delivery systems. The crystal systems must consistently incorporate the guest active pharmaceutical ingredient in terms of concentration and placement within the crystal lattice. The crystals also must grow under conditions which will not degrade or otherwise adversely affect the viability of the active pharmaceutical ingredient.

Preferred host crystal materials are those that have a high affinity for the included API. It appears that the oriented inclusion of the API's is related to the affinity between the crystal lattice component and the API. The affinity between these materials is therefore important in obtaining the desired inclusion of the API's, and also permits control of the inclusion based upon this affinity. For example, the concentration of the pharmaceutical in a crystal can be controlled by selecting the host component to have an affinity for the API which yields the desired inclusion rate. Also, mixtures of host materials, or of host materials and other excipients, can be used to provide an affinity yielding the desired inclusion level. In one aspect of the present invention, the API's are incorporated at levels of at least about 0.001% (w/w of guest:host), more preferably at least about 0.1% (w/w).

The preferred host crystal materials will also be very stable and readily crystallizable, and will maintain their "order" or crystal morphology when including a guest molecule, particularly large biomolecules. The use of particular host crystal components will also depend on such factors as how small or large the crystals can be produced and how readily they dissolve. For various routes of administration, it is desirable to have very small crystals (e.g., pulmonary), moderately sized crystals (e.g., injectable), or very large crystals (e.g., implantation and long term payout). The useful crystal sizes will therefore vary accordingly,

ranging from submicron to millimeter sizes. In one aspect of the present invention, the preferred crystals are in the order of 5-100 microns in size.

The useful host crystal systems are therefore diverse, and include various small molecule crystal systems which meet the desired criteria. Examples of pharmaceutically-acceptable crystal lattice components include sugars, polyhydroxy alcohols, single and polyamino acids, vitamins, salts, metals, preservatives, aromatic compounds especially aromatic acids, purified natural products, and polymers. Preferred crystal lattice components include, for example, sucrose, lactose, trehalose, maltose, galactose, sorbose, mannitol, lactitol, sorbitol, glycine, alanine, lysine, arginine, ascorbic acid, nicotinamide, thiamine, adenine, pyridoxine hydrochloride, caffeic acid, vanillic acid, ferulic acid, benzoate, sorbate, methyl paraben, sodium ascorbate, sodium saccharin, and potassium citrate. Also, compatible mixtures of these materials are also useful, and can be selected to obtain the desired rate of inclusion of the pharmaceutical, or to achieve desired characteristics, such as dissolution rate and pharmacokinetic profile, for the product crystals.

The crystal lattice components are selected to achieve the desired pharmacokinetics for the final crystals. As pertains to the present invention, the term "pharmacokinetics" is used to refer to the profile of the delivery of active pharmaceutical ingredient from the crystals into the circulatory system. This will depend primarily on the concentration of the active pharmaceutical ingredient in the crystals, as well as parameters of the active pharmaceutical ingredient itself. While given crystal lattice components will have associated inclusion and dissolution characteristics, these can be modified by including other crystal lattice components, other API's, or a variety of excipients. Thus, single crystals having two different, co-crystallized lattice components will typically be characterized by pharmacokinetic profiles different from crystals prepared with either of the crystal lattice components alone. Similarly, including excipients or other API's will provide altered rates of inclusion or dissolution for the resulting crystals, providing an associated modification in the pharmacokinetic profile for the resulting crystals.



In a related aspect, the present invention involves the use of mixtures of crystals having different pharmacokinetics in order to achieve desired payout profiles. For example, a pharmaceutical product can be obtained by combining two different types of crystals, one type of crystal using a first crystal lattice component characterized by a first pharmacokinetic profile, and the second type of crystal using a second crystal lattice component characterized by a second pharmacokinetic profile. The mixture of crystals will give a payout of API that is different from either of the individual payouts for the two crystal types.

The included API's are similarly diverse, limited simply by the requirements of compatibility with the host crystal and the crystal growth conditions. The active pharmaceutical ingredient cannot be unacceptably degraded or otherwise adversely affected by the conditions under which the crystals are formed. Also, the active pharmaceutical ingredient should remain stable for an extended period of time while included within the host crystal, and pharmaceutically efficacious upon release from the crystal.

Given the foregoing criteria, examples of API's useful in accordance with the present include: antibiotics (such as dirithromycin, loracarbef, tilmicosin, vancomycin, tylosin, monensin), fluoxetine, raloxifene, olanzapine, and nizatidine. A more complete list of API's useful in accordance with the present invention would include those identified in the following Table A.

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TABLE A

## Marketed Recombinant Protein Products

**Tissue Plasminogen Activator, T-PA**

- **Product name:** Activase (Generic name: Alteplase)
- **Produced by:** Genentech
- **Indication:** Human use, Acute myocardial infarction
- **Date of approval:** Nov 87, Patent expires on Dec 2000.
- **Formulation:** Intravenous injection. Lyophilized powder which is reconstituted with sterile water (supplied) to 1 mg/mL and results in a final pH of 7.3. Can not be reconstituted with preserved water due to precipitation. The 1 mg/mL solution can be diluted 1:1 with 0.9% NaCl or D5W and keep for 8 hours at room temperature. TPA is incapable with preservatives.

Ingredients	100 mg vial	50 mg vial	20 mg vial
T-PA	100 mg	50 mg	20 mg
L-Arginine	3.5 g	1.7g	0.7g
Phosphoric acid	1g	0.5g	0.2g
Polysorbate 80	<11 mg	<4 mg	<1.6 mg
Vacuum	No	Yes	Yes

- **Expression System:** Mammalian cell line (Chinese Hamster Ovary cells)
- **Refolding Conditions:**
- **Structure:** Glycoprotein of 527 amino acids, sequence from human melanoma cell line, activity of 580,000 IU/mg.
- **Additional Information:** Sales > \$100 million. Cost of therapy \$2,750 (100 mg).

**Interferon Gamma-1b**

- **Product name:** Actimmune
- **Produced by:** Genentech
- **Indication:** Human use, chronic granulomatous disease
- **Date of approval:** Dec 1990
- **Formulation:** Single dose solution formulation (0.5 mL), subcutaneous injection. Each 0.5 mL contains 100µg interferon gamma-1b, 20 mg mannitol, 0.36 mg sodium succinate, 0.05 mg polysorbate-20 in sterile water.
- **Expression System:** *E. coli*
- **Refolding Conditions:**
- **Post-Translational Modifications:**
- **Structure:** Single chain; Human sequence, 140 amino acids, 16,465 molecular weight, non-covalent dimeric form in solution, activity of 30 million units/mg.
- **Additional Information:** 14% injection site irritation vs. 2% in placebo. Cost \$140 for 50µg.

**Interferon alfa-n3 (natural source, not recombinant)**

- **Product name:** Alferon N
- **Produced by:** Interferon Science (New Brunswick, NJ)
- **Indication:** Human use, Genital Warts
- **Date of approval:** Jun 90
- **Formulation:** Preserved solution formulation (each mL contains 5 million IU of interferon alfa-n3 in phosphate buffered saline containing 3.3 mg phenol and 1 mg human albumin). Injected intralesional twice weekly for up to 8 weeks (50µL injected into each wart, 500µL total dose per treatment).
- **Expression System:** Natural source - human leukocytes which are exposed to an avian virus in order to produce interferon.
- **Refolding Conditions:** None
- **Structure:** Approximately 166 amino acids with a molecular weight ranging from 16 to 27 kDa, specific activity of 20,000 IU/mg or greater.
- **Additional Information:** Cost \$142 per mL.

**Beta Interferon 1a**

- **Product name:** Avonex
- **Produced by:** Biogen (Cambridge, MA)
- **Indication:** Human use, Multiple Sclerosis
- **Date of approval:** May 95

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TABLE A

- **Formulation:** Lyophilized powder (stored refrigerated or at 25°C for < 30 days) which is reconstituted with sterile water (supplied, 1.1 mL) to 30 µg/mL beta interferon 1a, 15 mg/mL human albumin, 5.8 mg/mL NaCl, 5.7 mg/mL dibasic Na phosphate, 1.2 mg/mL monobasic sodium phosphate, and has a pH of approximately 7.3 (recon solution is stable for 6 hours at refrigerated temperatures). Weekly intramuscular injection by patient or doctor (dosed for 1-2 years in clinical trials).
- **Expression System:** Mammalian cells (Chinese Hamster Ovary cells)
- **Refolding Conditions:**
- **Structure:** Glycoprotein (single N-linked complex carbohydrate), 166 amino acids with a predicted molecular weight of 22,500 daltons, human sequence, has a specific activity of 200 million units per mg protein.
- **Additional Information:** Cost \$180 per vial (33 µg)

**Interferon beta-1b**

- **Product name:** Betaseron
- **Produced by:** Berlex Laboratories (Wayne, NJ and Chiron, Emeryville, CA)
- **Indication:** Human use, Multiple Sclerosis
- **Date of approval:** July 93.
- **Formulation:** Lyophilized product (stored refrigerated) which is reconstituted with 0.54% NaCl (supplied) to 0.25 mg/mL interferon beta-1b, 12.5 mg/mL human albumin, 12.5 mg/mL dextrose, and has a pH of approximately 7.3 (recon solution is stable for 3 hours). Injected subcutaneously every other day (chronic use).
- **Expression System:** *E. coli*
- **Refolding Conditions:**
- **Structure:** 165 amino acids with an approximate molecular weight of 18,500 daltons, human sequence but with a serine or cysteine substitution at residue 17. Recombinant form does not contain the carbohydrate moiety found in the natural material. Has a specific activity of 32 million units per mg protein.
- **Additional Information:** Sales > \$500 million. Cost of therapy is \$13,140 (based on 0.25 mg/injection, dose every other day for 1 year; equals 46 mg protein).

**Interferon alfa-2b**

- **Product name:** Intron A
- **Produced by:** Schering-Plough (Madison, NJ)
- **Indication:** Human use, Hairy cell leukemia, genital warts, Hepatitis, Melanoma, Kaposi's sarcoma
- **Date of approval:** June 86
- **Formulation:** Comes in a lyophilized and a solution formulation. The lyophilized formulations when reconstituted with 0.9% benzyl alcohol (supplied) contains either 0.015, 0.025, 0.05, 0.90, or 0.125 mg/mL Interferon alfa-2b, 20 mg/mL glycine, 2.3 mg/mL sodium phosphate dibasic, 0.55 mg/mL sodium phosphate monobasic, and 1 mg/mL human albumin. The solution formulations contain either 0.05, 0.114, or 0.125 mg/mL Interferon alfa-2b, 20 mg/mL glycine, 2.3 mg/mL sodium phosphate dibasic, 0.55 mg/mL sodium phosphate monobasic, 1 mg/mL human albumin, 1.2 mg/mL methylparaben, and 0.12 mg/mL propylparaben. These formulations be injected intramuscular, subcutaneous, or intralesional. All formulations and reconstituted products are stored at refrigerated temperatures.
- **Expression System:** *E. coli*
- **Refolding Conditions:**
- **Structure:** Water soluble protein a molecular weight of 19,271 daltons. The Interferon alfa-2b gene is derived from human leukocytes.
- **Additional Information:** Sales > \$500 Million. Cost of therapy is \$16,445 (5 million units every day for 1 year, this is equal to 9 mg protein). Specific activity is 200 million units per mg protein

**Interferon alfa-2a**

- **Product name:** Roferon-A
- **Produced by:** Hoffmann-La Roche (Nutley, NJ)
- **Indication:** Human use, Hairy cell leukemia, Kaposi's sarcoma, myelogenous leukemia
- **Date of approval:** June 1986
- **Formulation:** Multi-use and lyophilized formulation indented for intramuscular or subcutaneous administration. Multi-use formulation contains either 0.015, 0.045, 0.090, 0.18 mg/mL Interferon alfa-2a, 9 mg/mL NaCl, 5 mg/mL human albumin, and 3 mg/mL phenol. The lyophilized formulation reconstituted with 3 mL of supplied diluent (6 mg/mL NaCl, 3.3 mg/mL phenol) consists of 0.03 mg/mL Interferon alfa-2a, 9 mg/mL NaCl, 1.67 mg/mL human albumin, and 3.3 mg/mL phenol.
- **Expression System:** *E. coli* (tetracycline promoter).

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TABLE A

- Refolding Conditions:
- Structure: Protein of 165 amino acids having a molecular weight of 19,000 daltons
- Additional Information: Cost of therapy is \$59,200 (28mg protein over 1 year). Specific activity is 200 million international units per mg protein.

**Human Growth Hormone (Somatropin)**

- Product name: BioTropin
- Produced by: Bio-Technology General (Iselin, NJ)
- Indication: Human use, Growth Deficiency
- Date of approval: May 95
- Formulation:
- Expression System:
- Refolding Conditions:
- Post-Transitional Modifications:
- Structure:
- Additional Information:

**Human Growth Hormone (Somatropin)**

- Product name: Genotropin
- Produced by: Pharmacia and Upjohn (Kalamazoo, MI)
- Indication: Human use, Growth Deficiency
- Date of approval: Aug 95
- Formulation:
- Expression System:
- Refolding Conditions:
- Structure:
- Additional Information:

**Human Growth Hormone (Somatropin)**

- Product name: Humatrope
- Produced by: Eli Lilly (Indianapolis, IN)
- Indication: Human use, Growth Deficiency
- Date of approval: March 87
- Formulation: Lyophilized product which is reconstituted with sterile water containing 0.3% m-cresol, 1.7% glycerin (supplied) to 2 mg/mL hGH and has a final pH of approximately 7.5, subcutaneous or intramuscular administration. Each 5 mg lyophilized vial contains 5 mg hGH, 25 mg mannitol, 1.13 mg dibasic sodium phosphate, and 5 mg glycine.
- Expression System: *E. coli*.
- Refolding Conditions:
- Structure: 191 amino acids, molecular weight of 22,125 daltons, sequence is identical to human pituitary-derived material.
- Additional Information: Cost \$210 per 5 mg hGH.

**Human Growth Hormone (Somatropin)**

- Product name: Norditropin
- Produced by: Novo Nordisk (Princeton, NJ)
- Indication: Human use, Growth Deficiency
- Date of approval: July 91
- Formulation:
- Expression System:
- Refolding Conditions:
- Post-Transitional Modifications:
- Structure:
- Additional Information:

**Human Growth Hormone (Somatropin)**

- Product name: Nutropin and Nutropin AQ
- Produced by: Genentech
- Indication: Human use, Growth Deficiency

TABLE A

- Date of approval: March 1994
- Formulation: Lyophilized product which is reconstituted with bacteriostatic water (0.9% benzyl alcohol, supplied) to 5 mg/mL hGH and has a final pH of approximately 7.4, subcutaneous or intramuscular administration. Each 5 mg lyophilized vial contains 5 mg hGH, 45 mg mannitol, 1.7 mg sodium phosphates (0.4 mg monobasic and 1.3 mg dibasic), and 1.7 mg glycine.
- Expression System: *E. coli*, expressed with a leading secretion signal precursor which directs the protein to the plasma membrane of the cell where the sequence is removed and the native protein is secreted into the periplasm so that the protein is folded appropriately as it is synthesized
- Refolding Conditions: None, expressed folded in *E. coli*.
- Structure: 191 amino acids, molecular weight of 22,125 daltons, sequence is identical to human pituitary-derived material.
- Additional Information: Cost \$420 per 10 mg hGH.

### **β-Glucocerebrosidase (imiglucerase)**

(β-D-glucosyl-N-acylsphingosine glucosylhydrolase, E.C.3.2.1.45)

- Product name: Cerezyme
- Produced by: Genzyme (Cambridge, MA)
- Indication: Human use, Gaucher's disease
- Date of approval: May 94
- Formulation: Lyophilized product (212 units glucocerebrosidase, 155 mg mannitol, 70 mg sodium citrate, and 0.53 mg polysorbate-80; stored refrigerated) is reconstituted with 5.1 mL of sterile water, final pH is approximately 6.1. The reconstituted material is combined with 100 to 200 mL of 0.9% NaCl and administered intravenously.
- Expression System: Mammalian cell culture (Chinese Hamster Ovary cells)
- Refolding Conditions:
- Structure: Monomeric glycoprotein of 497 amino acids, containing 4 N-linked glycosylation sites, molecular weight is 60,430 daltons. Recombinant protein differs from human placental glucocerebrosidase by a arginine substituted for histidine at position 495 and the glycosylation sites have been modified to terminate in mannose sugars (which are specifically recognized by endocytic carbohydrate receptors on macrophages, the cells that accumulate lipid in Gaucher disease).
- Additional Information: Orphan Drug, sales > \$100 million, Cost of therapy is \$351,130 (1 year).

### **Hepatitis B Surface Antigen**

- Product name: Engerix-B
- Produced by: SmithKline Beechman (Philadelphia, PA)
- Indication: Human use, Hepatitis B
- Date of approval: Sept 89
- Formulation: Suspension (20 µg/mL hepatitis B surface antigen adsorbed onto 0.5 mg aluminum, 1:20,000 thimerosal, 9 mg/mL NaCl, 1.7 mg/mL sodium phosphates). Intramuscular administration.
- Expression System: A portion of the hepatitis B virus gene, coding for hepatitis B surface antigen, is cloned into yeast (*Saccharomyces cerevisiae*)
- Refolding Conditions:
- Post-Transitional Modifications:
- Structure:
- Additional Information: Formulation contains no more than 5% yeast proteins.

### **Hepatitis B Surface Antigen**

- Product name: Recombivax HB
- Produced by: Merck (Whithouse Station, NJ)
- Indication: Human use, Hepatitis B prevention
- Date of approval: July 1986
- Formulation: Suspension (10 µg/mL hepatitis B surface antigen adsorbed onto 0.5 mg aluminum, 1:20,000 thimerosal). Intramuscular administration.
- Expression System: A portion of the hepatitis B virus gene, coding for hepatitis B surface antigen, is cloned into yeast (*Saccharomyces cerevisiae*)
- Refolding Conditions:
- Structure:
- Additional Information: Formulation contains no more than 1% yeast proteins.

### **Erythropoietin (rEPO)**

TABLE A

- **Product name:** Epogen or Epoetin alfa (Also sold under the name Procrit by Ortho Biotech but manufactured by Amgen)
- **Produced by:** Amgen (Thousand Oaks, CA)
- **Indication:** Human use, Anemia
- **Date of approval:** June 89, Patent expires in 2004 (December).
- **Formulation:** Two solution formulations, single dose and multi-dose. Single-dose is preservative free and each mL contains 2000, 3000, 4000, or 10000 units Epogen, 2.5 mg human albumin, 5.8 mg sodium citrate, 5.8 mg NaCl, and 0.06 mg citric acid in water for injection, pH 6.9 +/- 0.3. The preserved multi-dose product contains 10,000 units Epogen, 2.5 mg human albumin, 1.3 mg sodium citrate, 8.2 mg sodium chloride, 0.11 mg citric acid and 1% benzyl alcohol per mL of solution, pH is 6.1 +/- 0.3. Both solutions are stored refrigerated.
- **Expression System:** Mammalian cell
- **Refolding Conditions:**
- **Structure:** Glycoprotein of 165 amino acids having a molecular weight of 30,400 daltons, sequence identical to that of the human protein.
- **Additional Information:** Sales > \$500 million, Cost \$120 for 10,000 units.

#### Human Insulin

- **Product name:** Humulin
- **Produced by:** Eli Lilly (Indianapolis, IN)
- **Indication:** Human use, Diabetes
- **Date of approval:** Oct 82
- **Formulation:**
- **Expression System:** *E. Coli*
- **Refolding Conditions:**
- **Structure:**
- **Additional Information:** Sales > \$500 Million.

#### Human Insulin

- **Product name:** Novolin
- **Produced by:** Novo Nordisk (Princeton, NJ)
- **Indication:** Human use, Diabetes
- **Date of approval:** July 91
- **Formulation:**
- **Expression System:**
- **Refolding Conditions:**
- **Post-Translational Modifications:**
- **Structure:**
- **Additional Information:**

#### LysPro Human Insulin

- **Product name:** Humalog
- **Produced by:** Eli Lilly (Indianapolis, IN)
- **Indication:** Human use, Diabetes
- **Date of approval:** June 1996
- **Formulation:**
- **Expression System:**
- **Refolding Conditions:**
- **Post-Translational Modifications:**
- **Structure:**
- **Additional Information:**

#### GM-CSF (Granulocyte Macrophage-Colony Stimulating Factor)

- **Product name:** Leukine
- **Produced by:** Immunex (Seattle, WA)
- **Indication:** Human use, Bone marrow transplantation, Hodgkin's Disease, Leukemia
- **Date of approval:** Mar 91
- **Formulation:** Lyophilized solution which is reconstituted with sterile water (stored at refrigerated temperatures for < 6 hours) or 0.9% benzyl alcohol (can be stored for < 20 days at refrigerated

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TABLE A

temperatures) and administered intravenous. After reconstitution, the lyophilized single use product contains either 0.25 mg/mL or 0.50 mg/mL GM-CSF, 40 mg/ml mannitol, 10 mg/ml sucrose, and 1.2 mg/ml tromethamine (final pH is 7.4 +/- 0.3). The reconstituted solution is then diluted into a 0.9% NaCl bag for IV administration (note if final GM-CSF is below 0.01 mg/mL add human albumin to 0.1% to prevent adsorption to the IV bag).

- Expression System: Yeast (*S. Cerevisiae*)
- Refolding Conditions: None, expressed folded.
- Structure: Glycoprotein of 127 amino acids characterized by 3 primary molecular species having molecular masses of 19,500, 16800, and 15500 daltons. The primary sequence differs from natural human GM-CSF by a substitution of leucine at position 23, and the carbohydrate moiety may be different from native.
- Additional Information: Specific activity is  $5 \times 10^7$  colony forming units per mg protein. Sargramostim is the proper name for yeast-derived recombinant GM-CSF. Cost for a 0.5 mg GM-CSF vial is \$178.

### G-CSF (Granulocyte Colony Stimulating Factor)

- Product name: Neupogen
- Produced by: Amgen (Thousand Oaks, CA)
- Indication: Human use, Neutropenia, bone marrow transplantation, anemia
- Date of approval: Feb 91
- Formulation: Single-use solution formulation containing 0.3 mg/mL G-CSF, 10 mM sodium acetate, 5% mannitol, and 0.004% Tween-80 at a pH of 4. The product is to be stored at refrigerated temperatures and no more than 24 hours at room temperature. If required, Neupogen can be diluted with D5W (do not dilute with saline at any time; product may precipitate), at concentrations below 5 to 15 µg/mL, add human albumin to 2 mg/mL to prevent adsorption to IV bag.
- Expression System: *E. coli*.
- Refolding Conditions:
- Structure: A 175 amino acid protein with a molecular weight of 18,800 daltons. The protein has an amino acid sequence identical to the human protein except for an additional N-terminal methionine (necessary for expression in *E. coli*). The human protein is glycosylated but the recombinant Neupogen is not.
- Additional Information: Sales > \$500 million. Filgrastim is the name given to recombinant methionyl human G-CSF. Cost of therapy (lung cancer) is \$2,130 (4.2 mg protein over 14 days). Specific activity is 30 million units per mg protein.

### Satumomab Pendetide

- Product name: OncoScint CR/OV
- Produced by: Cytogen (Princeton, NJ)
- Indication: Human use, Colorectal and ovarian cancers
- Date of approval: Dec 92
- Formulation:
- Expression System:
- Refolding Conditions:
- Post-Translational Modifications:
- Structure:
- Additional Information:

### Interleukin-2

- Product name: Proleukin (generic name: Aldesieukin)
- Produced by: Chiron (Emeryville, CA)
- Indication: Human use, Renal cell carcinoma
- Date of approval: May 1992
- Formulation: Single-use lyophilized formulation which is reconstituted with 1.2 mL sterile water and administered intravenously. Each reconstituted product contains 1.1 mg/mL Proleukin, 50 mg/ml mannitol, and 0.18 mg/ml dibasic sodium phosphate (pH is 7.5 +/- 0.3). Lyophilized product is stored at refrigerated temperatures, reconstituted product is stable up to 48 hours at refrigerated to room temperatures, but should be stored in refrigerator due to lack of preservatives. Addition of preservatives results in increased aggregation, addition of human albumin alters pharmacology.
- Expression System: *E. coli* (tetracycline promoter).
- Refolding Conditions:

TABLE A

- **Structure:** Proleukin has a molecular weight of 15,300 daltons and differs from the natural human protein (is not glycosylated, the N-terminal alanine is removed, and has a serine substituted for the free cysteine at position 125)
- **Additional Information:** Specific activity is 18 million international units per 1.1 mg protein. Cost is \$395 per 1.3 mg protein.

**Somatrem**

- **Product name:** Protropin
- **Produced by:** Genentech (S. San Francisco, CA)
- **Indication:** Human use, Growth deficiency
- **Date of approval:** Oct 1985, patent expired on Oct 1992.
- **Formulation:** Lyophilized formulation which is reconstituted with 0.9% benzyl alcohol (supplied) and administered intramuscular or subcutaneous. The lyophilized vial contains 5 mg Somatrem, 40 mg mannitol and 1.7 mg sodium phosphates (0.1 mg sodium phosphate monobasic and 1.6 mg sodium phosphate dibasic) and is reconstituted with 1 to 5 mL of 0.9% benzyl alcohol. The lyophilized product is stored at refrigerated temperatures, the reconstituted product is good for 14 days at refrigerated temperatures.
- **Expression System:** *E. coli*.
- **Refolding Conditions:**
- **Structure:** Contains 192 amino acids with a molecular weight of 22,000 daltons. Identical to human sequence but contains an extra methionine at the N-terminus.
- **Additional Information:** Sales > \$100 million. Cost of therapy is \$13,110 (1 year, 313 mg protein)

**DNase (deoxyribonuclease I)**

- **Product name:** Pulmozyme
- **Produced by:** Genentech (S. San Francisco, CA)
- **Indication:** Human use, Cystic fibrosis
- **Date of approval:** Dec 1993
- **Formulation:** Inhalation solution (aerosol mist produced by a compressed air driven nebulizer system). Comes in a single-use 2.5 mL ampule containing 1.0 mg/mL DNase, 0.15 mg/mL calcium chloride dihydrate, and 8.77 mg/ml sodium chloride, at a pH of 6.3. The solution is stored at refrigerated temperatures and should not be exposed to light.
- **Expression System:** Mammalian cells (Chinese hamster Ovary cells)
- **Refolding Conditions:**
- **Structure:** Glycoprotein of 260 amino acids having a molecular weight of 37,000 daltons. The primary sequence is identical to that of the native human enzyme.
- **Additional Information:** Sales > \$100 Million. Cost is \$32 for 2.5 mg of protein (1 ampule)

**M-CSF (Macrophage-Colony Stimulating Factor)**

- **Product name:** Leucomax (generic name: Molgramostim)
- **Produced by:**
- **Indication:** Human use,
- **Date of approval:** FDA unapproved
- **Formulation:**
- **Expression System:**
- **Refolding Conditions:**
- **Post-Translational Modifications:**
- **Structure:**
- **Additional Information:**

**Epoetin Beta (Erythropoietin)**

- **Product name:** Marogen
- **Produced by:**
- **Indication:** Human use,
- **Date of approval:**
- **Formulation:**
- **Expression System:**
- **Refolding Conditions:**
- **Post-Translational Modifications:**



TABLE A

- Structure:
- Additional Information:

**Polyribonucleotide**

- Product name: Ampligen
- Produced by:
- Indication: Human use,
- Date of approval: FDA Unapproved
- Formulation:
- Expression System:
- Refolding Conditions:
- Post-Transitional Modifications:
- Structure:
- Additional Information:

**Human Serum Albumin**

- Product name:
- Produced by:
- Indication: Human use,
- Date of approval:
- Formulation:
- Expression System:
- Refolding Conditions:
- Post-Transitional Modifications:
- Structure:
- Additional Information:

**Septomonab?**

- Product name: Genoxin
- Produced by:
- Indication: Human use,
- Date of approval: Not FDA approved
- Formulation:
- Expression System:
- Refolding Conditions:
- Post-Transitional Modifications:
- Structure:
- Additional Information:

**Protein**

- Product name:
- Produced by:
- Indication: Human use,
- Date of approval:
- Formulation:
- Expression System:
- Refolding Conditions:
- Post-Transitional Modifications:
- Structure:
- Additional Information:

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TABLE A

## APPROVED BIOTECHNOLOGY DRUGS AND VACCINES

Product Name	Company	Product Category	Indication
Comvax™ <i>Haemophilus b</i> conjugate (meningococcal protein conjugate) and hepatitis b (recombinant) vaccine	Merck Whitehouse Station, NJ.	recombinant vaccine	vaccination of infants beginning at two months of age against both invasive <i>Haemophilus influenzae</i> type b diseases (Hib) and hepatitis B (October 1996)
Engerix-B® hepatitis B vaccine (recombinant)	SmithKline Beecham Philadelphia, PA	recombinant vaccine	hepatitis B (September 1989)
EPOCEN® Epoetin alfa (rEPO)	Amgen Thousand Oaks, CA	erythropoietin	treatment of anemia associated with chronic renal failure, including patients on dialysis and not on dialysis, and anemia in Retrovir®-treated HIV-infected patients (June 1989); treatment of anemia caused by chemotherapy in patients with non-myeloid malignancies (April 1993); prevention of anemia associated with surgical blood loss, autologous blood donation adjuvant (December 1996)
PROCRIT® Epoetin alfa (rEPO)	Ortho Biotech Raritan, NJ	erythropoietin	treatment of anemia associated with chronic renal failure, including patients on dialysis and not on dialysis, and anemia in Retrovir®-treated HIV-infected patients (December 1990); treatment of anemia caused by chemotherapy in patients with non-myeloid malignancies (April 1993); prevention of anemia associated with surgical blood loss, autologous blood donation adjuvant (December 1996)
[PROCRIT was approved for marketing under Amgen's epoetin alfa PLA. Amgen manufactures the product for Ortho Biotech.] Under an agreement between the two companies, Amgen licensed to Ortho Pharmaceutical the U.S. rights to epoetin alfa for indications for human use excluding dialysis and diagnostics.			
Genotropin™ somatotropin (rDNA origin) for injection	Pharmacia & Upjohn Kalamazoo, MI	human growth hormone	short stature in children due to growth hormone deficiency (August 1995)
Genef® human growth hormone releasing factor	Serono Laboratories Norwell, MA	growth factor	evaluation of the ability of the somatotroph of the pituitary gland to secrete growth hormone (December 1990); pediatric growth hormone deficiency (October 1997)
Gonal-F® recombinant human follicle-stimulating hormone (r-FSH)	Serono Laboratories Norwell, MA	recombinant fertility hormone	female infertility (September 1997)
Humalog™ insulin lispro	Eli Lilly Indianapolis, IN	recombinant insulin	diabetes (June 1996)
Humatrope® somatotropin (rDNA origin) for injection	Eli Lilly Indianapolis, IN	human growth hormone	human growth hormone deficiency in children (March 1987)

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TABLE A

## APPROVED BIOTECHNOLOGY DRUGS AND VACCINES

Product Name	Company	Product Category	Indication
Humulin® human insulin (recombinant DNA origin)	Eli Lilly Indianapolis, IN	recombinant insulin	diabetes (October 1982)
Infergen® interferon alfacon-1	Amgen Thousand Oaks, CA	interferon	treatment of chronic hepatitis C viral infection (October 1997)
Intron® A interferon alfa-2b (recombinant)	Schering-Plough Madison, NJ	interferon	hairy cell leukemia (June 1986); genital warts (June 1988); AIDS-related Kaposi's sarcoma (November 1988); hepatitis C (February 1991); hepatitis B (July 1992); malignant melanoma (December 1995); follicular lymphoma in conjunction with chemotherapy (November 1997)
KoGENate® antihemophilic factor (recombinant)	Bayer Corporation, Pharmaceutical Division West Haven, CT	clotting factor	treatment of hemophilia A (February 1993)
Leukine™ sargramostim (GM-CSF)	Immunex Seattle, WA	colony stimulating factor	autologous bone marrow transplantation (March 1991); neutropenia resulting from chemotherapy in acute myelogenous leukemia (September 1995); allogeneic bone marrow transplantation (November 1995); peripheral blood progenitor cell mobilization and transplantation (December 1995)
MyoScint® imicromab peniclate	Centocor Malvern, PA	MAB	myocardial infarction imaging agent (July 1996)
Neumega® oprelvekin	Genetics Institute Cambridge, MA	MAB	prevention of severe chemotherapy-induced thrombocytopenia (November 1997)
NEUPOGEN® Filgrastim (rG-CSF)	Amgen Thousand Oaks, CA	colony stimulating factor	chemotherapy-induced neutropenia (February 1991); autologous or allogeneic bone marrow transplantation (June 1994); chronic severe neutropenia (December 1994); support peripheral blood progenitor cell transplantation (December 1995)
Norditropin® somatotropin (rDNA origin) for injection	Novo Nordisk Pharmaceuticals Princeton, NJ	human growth hormone	treatment of growth failure in children due to inadequate growth hormone secretion (May 1995)
Novolin® 70/30 70% NPH human insulin isophane suspension & 30% regular, human insulin injection (recombinant DNA origin)	Novo Nordisk Pharmaceuticals Princeton, NJ	recombinant insulin	insulin-dependent diabetes mellitus (July 1991)
Novolin® L Lente®, human insulin zinc suspension (recombinant DNA origin)	Novo Nordisk Pharmaceuticals Princeton, NJ	recombinant insulin	insulin-dependent diabetes mellitus (July 1991)

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TABLE A

## APPROVED BIOTECHNOLOGY DRUGS AND VACCINES

Product Name	Company	Product Category	Indication
Novolin® N NPH, human insulin isophane suspension (recombinant DNA origin)	Novo Nordisk Pharmaceuticals Princeton, NJ	recombinant insulin	insulin-dependent diabetes mellitus (July 1991)
Novolin® R regular, human insulin injection (recombinant DNA origin)	Novo Nordisk Pharmaceuticals Princeton, NJ	recombinant insulin	insulin-dependent diabetes mellitus (July 1991)
Nutropin® somatropin for injection	Genentech S. San Francisco, CA	human growth hormone	growth failure in children due to chronic renal insufficiency, growth hormone inadequacy in children (March 1994); Turner's syndrome (December 1996); growth hormone inadequacy in adults (December 1997)
Nutropin AQ™ somatropin (liquid)	Genentech S. San Francisco, CA	human growth hormone	growth failure in children due to chronic renal insufficiency, growth hormone inadequacy in children (December 1995); Turner's syndrome (December 1996); growth hormone inadequacy in adults (December 1997)
OncoScint® CROV satumomab pendetide	CYTOGEN Princeton, NJ	MAB	detection, staging and follow-up of colorectal and ovarian cancers (December 1992)
ORTHOCLONE OKT®3 muromonab-CD3	Ortho Biotech Raritan, NJ	MAB	reversal of acute kidney transplant rejection (June 1986); reversal of heart and liver transplant rejection (June 1993)
Proleukin® aldesleukin (interleukin-2)	Chiron Emeryville, CA	interleukin	renal cell carcinoma (May 1992); metastatic melanoma (January 1998)
ProstaScint® capromab pentetate	CYTOGEN Princeton, NJ	MAB	detection, staging and follow-up of prostate adenocarcinoma (October 1996)
Protropin® somatrem for injection	Genentech S. San Francisco, CA	human growth hormone	human growth hormone deficiency in children (October 1985)
Pulmozyme® dornase alpha, recombinant	Genentech S. San Francisco, CA	recombinant DNase	cystic fibrosis (December 1993); management of advanced cystic fibrosis (December 1996)
Recombinant™ antihemophilic factor recombinant (rAHF)	Baxter Healthcare/ Hyland Division Glendale, CA Genetics Institute Cambridge, MA	clotting factor	hemophilia A (December 1992)
RECOMBIVAX HB® hepatitis B vaccine (recombinant), MSD	Merck Whitehouse Station, NJ	recombinant vaccine	hepatitis B prevention (July 1986)
Refudan™ lepirudin (rDNA) for injection	Hoechst Marion Roussel Kansas City, MO	recombinant anticoagulant	heparin-induced thrombocytopenia type II (March 1998)

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TABLE A

## APPROVED BIOTECHNOLOGY DRUGS AND VACCINES

Product Name	Company	Product Category	Indication
Regranex® becaplermin	Ortho-McNeil Pharmaceuticals Raritan, NJ	growth factor	lower extremity diabetic neuropathic ulcers (December 1997)
ReoPro® abciximab	Centocor Malvern, PA Eli Lilly Indianapolis, IN	MAB	anti-platelet prevention of blood clots in the setting of high-risk percutaneous transluminal coronary angioplasty (December 1994); refractory unstable angina when percutaneous coronary intervention is planned (November 1997)
Retavase™ reteplase	Boehringer Mannheim Gaithersburg, MD Centocor Malvern, PA	tissue plasminogen factor	treatment of acute myocardial infarction (October 1996)
Rituxan® rituximab	Genentech S. San Francisco, CA IDEC Pharmaceuticals San Diego, CA	MAB	treatment of relapsed or refractory low-grade or follicular CD20-positive B-cell non-Hodgkin's lymphoma (November 1997);
Roferon®-A interferon alfa-2a, recombinant	Hoffmann-La Roche Nutley, NJ	interferon	hairy cell leukemia (June 1986); AIDS-related Kaposi's sarcoma (November 1988); chronic myelogenous leukemia (November 1995); hepatitis C (November 1996)
Saizen® somatropin (rDNA origin) for injection	Serono Laboratories Norwell, MA	human growth hormone	pediatric growth hormone deficiency (October 1996)
Serosim™ somatropin (rDNA origin) for injection	Serono Laboratories Norwell, MA	human growth hormone	treatment of AIDS-associated catabolism/wasting (August 1996); pediatric HIV failure to thrive (February 1998)
Verluma® nifedipine	Boehringer Ingelheim Ridgefield, CT NeoRx Seattle, WA	MAB	detection of small-cell lung cancer (August 1996)
Veride® cidofovir injection	Gilead Sciences Foster City, CA	nucleotide analogue	cytomegalovirus retinitis in AIDS patients (June 1996)
Zenapax® daclizumab	Hoffmann-La Roche Nutley, NJ	MAB	prevention of acute kidney transplant rejection (December 1997)

The content of this survey has been obtained through government and industry sources based on the latest information. The information may not be comprehensive. For more specific information about a particular product, contact the individual company directly.

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# Biotechnology Medicines in Development

## AIDS/HIV INFECTION AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
AD-439 and AD-519 combination	Tanox Biosystems Houston, TX	MAb	HIV infection, AIDS	Phase II
AD-439 MAb, anti-HIV to V3 loop of gp120 protein; neutralizing antibody	Tanox Biosystems Houston, TX	MAb	HIV infection, AIDS	Phase II
AD-519 MAb, anti-HIV to C4 region of gp120 protein; neutralizing antibody	Tanox Biosystems Houston, TX	MAb	HIV infection, AIDS	Phase II
Alferon LDO® interferon alfa-n3	Interferon Sciences New Brunswick, NJ	interferon	AIDS-related complex, AIDS	Phase VII
Alferon N injection® interferon alfa-n3	Interferon Sciences New Brunswick, NJ	interferon	HIV infection (see also infectious diseases)	Phase III
			co-infection (HIV/HCV)	Phase II
ALVAC-MN 12-TMG (vCP205)	Pasteur Merieux Connaught Lyons, France Virogenetics Albany, NY	vaccine	HIV infection	Phase II
Ampligen®	Hemispherx Biopharma New York, NY	interferon	HIV infection (see also cancer, infectious diseases, other)	Phase II
autologous gene-modified hematopoietic stem cells	SyStemix Palo Alto, CA	gene therapy	HIV infection	Phase I
gene therapy	Cell Genesys Foster City, CA Hoechst Marion Roussel Kansas City, MO	gene therapy	HIV infection	Phase II
gp120 vaccine	VaxGen S. San Francisco, CA	vaccine	AIDS	Phase II
HIV-IT(V) Retrovector™ HIV-1 IIIIB env/rev retroviral vector	Chiron Viagene San Diego, CA	gene therapy	asymptomatic HIV-1 infection	Phase II
HIV vaccine (gp120)	Chiron Emeryville, CA	vaccine	AIDS	Phase II
interleukin-10 (IL-10)	Schering-Plough Madison, NJ	interleukin	HIV disease (see also autoimmune, digestive, heart, neurologic, respiratory, skin)	Phase I

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TABLE A

## AIDS/HIV INFECTION AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
ISIS 2922 fomivirsen	Isis Pharmaceuticals Carlsbad, CA	antisense	cytomegalovirus retinitis	Phase III
ISIS 13312	Isis Pharmaceuticals Carlsbad, CA	antisense	cytomegalovirus retinitis	Phase I
Leukine™ sargramostim (GM-CSF)	Immunex Seattle, WA	colony stimulating factor	adjuvant to AIDS therapy, HIV infection, prevention of infection in HIV patients (see also cancer)	Phase II
memantine	Neurobiological Technologies Richmond, CA		AIDS dementia complex and AIDS-related neuropathic pain (see also diabetes)	Phase II
MPL® immunomodulator vaccine	Ribi ImmunoChem Hamilton, MT	vaccine	AIDS (see also infectious diseases)	Phase I
NEUPOGEN® Filgrastim (rG-CSF)	Amgen Thousand Oaks, CA	colony stimulating factor	treatment and prevention of neutropenia in HIV patients (see also cancer, respiratory)	application submitted
Ovidrel® recombinant human chorionic gonadotropin (r-hCG)	Ares-Serono and Serono Laboratories Norwell, MA	recombinant gonadotropin	Kaposi's sarcoma, AIDS-related hypogonadism (see also infertility)	Phase IV
PEG interleukin-2	Chiron Emeryville, CA	interleukin	HIV infection in combination with Retrovir®	Phase II
PMPA	Gilead Sciences Foster City, CA	nucleotide analogue	HIV infection, AIDS	Phase II
Preveon™ zidovir dipivoxil	Gilead Sciences Foster City, CA	nucleotide analogue	HIV infection, AIDS	Phase III
PRO 367	Progenics Pharmaceuticals Tarrytown, NY		HIV infection	Phase I
PRO 542	Progenics Pharmaceuticals Tarrytown, NY		HIV infection	Phase I
Proleukin® aldesleukin (interleukin-2)	Chiron Emeryville, CA	interleukin	HIV infection in combination with Retrovir® (see also cancer)	Phase II/III
Rensune HIV-1 immunogen	Immune Response Corp. Carlsbad, CA	immune- based therapy	HIV seropositive	Phase III
retroviral vector with 2 ribozymes	Chiron Emeryville, CA	gene therapy	HIV infection	Phase VII
TBC-38 (vaccinia virus expressing HIV genes env, gag and pol)	Therion Biologics Cambridge, MA	vaccine	AIDS prevention	Phase I

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TABLE A

## AUTOIMMUNE DISORDERS

Product Name	Company	Product Category	Indication	Development Status
adenosine deaminase-transduced autologous CD34+ PBC or umbilical cord/placental blood cells	National Cancer Institute Bethesda, MD	gene therapy	severe combined immunodeficiency	Phase I NCI TRIAL
adenosine deaminase-transduced T cells	National Cancer Institute Bethesda, MD	gene therapy	severe combined immunodeficiency	Phase I NCI TRIAL
Anergix™-RA	Anergen Redwood City, CA	functional antigenic immunotherapy	rheumatoid arthritis	Phase I
AnervaX™	Anergen Redwood City, CA	peptide vaccine	rheumatoid arthritis	Phase II
Avakine™ chimeric anti-TNF antibody	Centocor Malvern, PA	MAB	rheumatoid arthritis (see also digestive)	Phase III
CD40 ligand antibody	Biogen Cambridge, MA	MAB	lupus, immune thrombocytopenic purpura	Phase II
clenolisimab	IDEC Pharmaceuticals San Diego, CA SmithKline Beecham Philadelphia, PA	MAB	rheumatoid arthritis	Phase II
ConXn™ relaxin	Connetics Palo Alto, CA	recombinant human protein	scleroderma	Phase II
Enbrel tumor necrosis factor (TNF) receptor	Immunex Seattle, WA Wyeth-Ayerst Laboratories Philadelphia, PA	recombinant soluble receptor	rheumatoid arthritis	Phase III
hSG1.1	Alexion Pharmaceuticals New Haven, CT	MAB	lupus, rheumatoid arthritis	Phase VI
IDEC-131 humanized MAB	IDEC Pharmaceuticals San Diego, CA	MAB	systemic lupus erythematosus	Phase I
IL-2 fusion protein DAB <sub>1</sub> /IL-2	Seragen Hopkinton, MA	fusion protein	severe rheumatoid arthritis (see also cancer, skin)	Phase VI
Interleukin-10 (IL-10)	Schering-Plough Madison, NJ	interleukin	rheumatoid arthritis (see also AIDS/HIV, digestive, heart, neurologic, respiratory, skin)	Phase II
IR 501 therapeutic vaccine	Immune Response Corp. Carlsbad, CA	vaccine	rheumatoid arthritis	Phase II
ISIS 2302	Isis Pharmaceuticals Carlsbad, CA	antisense	rheumatoid arthritis (see also digestive, skin, transplantation)	Phase II

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TABLE A

# **AUTOIMMUNE DISORDERS**

Product Name	Company	Product Category	Indication	Development Status
MDX-33	Medarex Annandale, NJ	MAb	autoimmune diseases, idiopathic thrombocytopenic purpura	Phase I
ORTHOCLONE OKT4A	Ortho Biotech Raritan, NJ	MAb	treatment of CD4-mediated autoimmune diseases (see also transplantation)	Phase II
Quadralone interleukin-4 (IL-4)	Schering-Plough Madison, NJ	interleukin	rheumatoid arthritis	Phase I
SMART™ Anti-CD3 HuM291	Protein Design Labs Mountain View, CA	MAb	autoimmune diseases (see also transplantation)	Phase I

# **BLOOD DISORDERS**

Product Name	Company	Product Category	Indication	Development Status
CPC-111	Cypros Pharmaceuticals Carlsbad, CA	cellular therapy	sickle cell disease (see also heart)	Phase II
Factor VIII	Transkaryotic Therapies Cambridge, MA	gene therapy	hemophilia A	Phase I
GA-EPO	Hoechst Marion Roussel Kansas City, MO Transkaryotic Therapies Cambridge, MA	erythropoietin	anemia associated with chronic renal failure	Phase II
Kogenate-N rFVIII	Bayer Berkeley, CA	clotting factor	hemophilia A	Phase III
NovoSeven® recombinant factor VIIa	Novo Nordisk Pharmaceuticals Princeton, NJ	clotting factor	treatment of hemophilia A&B with and without antibodies against factors VIII/IX	Phase III
Optro™ recombinant human hemoglobin (rHb1.1)	Somatogen Boulder, CO	recombinant human hemoglobin	oxygen-carrying agent and alternative to red blood cell transfusion	Phase II
			stimulation of red blood cell formation	Phase I
ReFacto® recombinant factor VIII	Genetics Institute Cambridge, MA	clotting factor	hemophilia A	Phase III
YM-337 MAb	Yamanouchi USA White Plains, NY Protein Design Labs Mountain View, CA	MAb	platelet aggregation	Phase I

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TABLE A

## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
131I-chTNT-1/B	Techniclone Tustin, CA	MAB	malignant glioma	Phase I
Aastrom™ Cell Production System stem and progenitor cell expansion from bone marrow and umbilical cord blood	Aastrom Biosciences Ann Arbor, MI	cellular therapy	cancer immunosuppression/ blood and immune system recovery for patients receiving ablative chemotherapy	Phase II
Actimmune® interferon gamma-1b	National Cancer Institute Bethesda, MD Genentech S. San Francisco, CA	interferon	colon, lung, ovarian, prostate cancers, melanoma	Phase II NCI TRIAL
AFP-Scan™ technetium-99m- FAB' fragment (germ cell)	Immunomedics Morris Plains, NJ	MAB	extent of disease staging of liver and germ cell cancers	Phase II
allogeneic hematopoietic stem cell transplantation	SyStemix Palo Alto, CA	cellular therapy	advanced leukemia, lymphoma, myelodysplastic syndromes	Phase I
Allovectin-7 DNA/lipid complex encoding HLA-B7 antigen	Vical San Diego, CA	gene therapy	advanced metastatic melanoma, non-resectable squamous cell carcinoma of the head and neck	Phase II
ALT (autolymphocyte therapy)	Cellcor Newton, MA CYTOGEN Princeton, NJ	cellular therapy	metastatic renal cell carcinoma (kidney cancer)	Phase III completed
ALVAC-B7.1	National Cancer Institute Bethesda, MD	gene therapy	melanoma	Phase I NCI TRIAL
ALVAC-CEA-B7.1	National Cancer Institute Bethesda, MD	gene therapy	advanced adenocarcinomas	Phase I NCI TRIAL
ALVAC-CEA vaccine	National Cancer Institute Bethesda, MD	vaccine	advanced cancers	Phase I NCI TRIAL
ALVAC-IL-12 vaccine	National Cancer Institute Bethesda, MD Pasteur Merieux Connaught Lyons, France	vaccine	melanoma	Phase I NCI TRIAL
Ampligen®	Hemispherix Biopharma New York, NY	interferon	renal cancer (see also AIDS/HIV, infectious diseases, other)	Phase I/II
anti-cancer T-cell gene therapy	Cell Genesys Foster City, CA	gene therapy	colon cancer	Phase I/II
anti-idiotypic monoclonal antibody	Novartis Pharmaceuticals East Hanover, NJ	MAB	cancer	Phase I

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TABLE A

## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
anti-Tac(Fv)-PE38 immunotoxin	National Cancer Institute Bethesda, MD	MAB+toxin	leukemia, lymphoma	Phase I NCI TRIAL
anti-transferrin receptor MAb	National Cancer Institute Bethesda, MD	MAB	advanced, refractory solid tumors	Phase I NCI TRIAL
anti-VEGF humanized MAB	Genentech S. San Francisco, CA	MAB	cancer	Phase I
autologous hematopoietic stem cells for autologous hematopoietic transplantation	Systemix Palo Alto, CA	cellular therapy	hematopoietic reconstruction in patients with multiple myeloma, non-Hodgkin's lymphoma, breast cancer	Phase I/II
autologous peptide-specific activated lymphocytes	National Cancer Institute Bethesda, MD	cellular therapy	advanced solid tumors	Phase I NCI TRIAL
autologous transduced CD34+ bone marrow and peripheral blood stem cells	National Cancer Institute Bethesda, MD	gene therapy	breast cancer, myeloma	Phase I NCI TRIAL
Avicidin® MAB conjugate	Janssen Pharmaceutica Titusville, NJ NeoRx Seattle, WA	MAB	colorectal, lung, prostate cancers	Phase II
Avicine™ CTP-37	AVI BioPharma Portland, OR	vaccine	colorectal, pancreatic cancers	Phase II
Avonex® interferon beta-1A	Biogen Cambridge, MA	interferon	glioma (see also neurologic)	Phase II
B7 transfected allogeneic melanoma cell vaccine	National Cancer Institute Bethesda, MD	vaccine	melanoma	Phase I NCI TRIAL
BEC2, anti-idiotypic MAB	ImClone Systems Somerville, NJ	vaccine	melanoma, small-cell lung cancer	Phase I
Betaseron® recombinant beta interferon-1b	National Cancer Institute Bethesda, MD Berlex Laboratories Wayne, NJ	interferon	non-small-cell lung cancer (see also neurologic)	Phase III NCI TRIAL
bispecific antibody	Chiron Emeryville, CA	MAB	cancer	Phase I
C225, anti-EGFR chimeric MAB	ImClone Systems Somerville, NJ	MAB	epidermal growth factor receptor positive cancers	Phase II
Campath 1H	LeukoSite Cambridge, MA	MAB	chronic lymphocytic leukemia	In clinical trials

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TABLE A

## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
carcinoembryonic antigen peptide-1 vaccine	National Cancer Institute Bethesda, MD	vaccine	breast, gastrointestinal tract, lung cancers	Phase I NCI TRIAL
CEACide™ humanized anti-CEA antibody (hMN14)	Immunomedics Morris Plains, NJ	MAB	colorectal cancer	Phase II
CEA-Scan™ technetium-99m- arctumomab (breast)	Immunomedics Morris Plains, NJ	MAB	extent of disease staging of breast cancer	Phase II
CEA-Scan™ technetium-99m- arctumomab (lung)	Immunomedics Morris Plains, NJ	MAB	extent of disease staging of lung cancer	Phase III
CEAVac™ anti-idiotypic antibody vaccine	Titan Pharmaceuticals S. San Francisco, CA	vaccine	colorectal cancer	Phase II
cell therapy	CytoTherapeutics Providence, RI	cellular therapy	cancer pain, untreatable/unrelieved by other forms of treatment	Phase II
Cereport™ (RMP-7) and carboplatin	Alkermes Cambridge, MA		recurrent malignant brain tumor	Phase III
chemotherapy- resistant bone marrow	Genetix Rye, NY	gene therapy	treatment of cancer patients requiring chemotherapy	Phase I/II
chimeric MAB 14.18	National Cancer Institute Bethesda, MD	MAB	melanoma, neuroblastoma	Phase II NCI TRIAL
CM 101	CarboMed Brentwood, TN		cancer	Phase I/II
CMA-676	Wyeth-Ayerst Laboratories Philadelphia, PA	MAB	relapsed acute myelogenous leukemia	Phase II/III
CMB-401	Wyeth-Ayerst Laboratories Philadelphia, PA	MAB	ovarian cancer	Phase I/II
colon cancer cell line vaccine	Immune Response Corp. Carlsbad, CA Sidney Kimmel Cancer Center San Diego, CA	vaccine	colon cancer	Phase I
CP-358,774	OSI Pharmaceuticals Uniondale, NY Pfizer New York, NY	cellular therapy	cancer	Phase I
CT-2584	Cell Therapeutics Seattle, WA		ovarian, prostate cancer, sarcoma	Phase I
cytosine deaminase gene-adenoviral vector	GenVec Rockville, MD	gene therapy	colon cancer	Phase I

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## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
DA/Hu(gamma).4 (hIFN- $\gamma$ VI) Retrovector™ hIFN- $\gamma$ retroviral vector	Chiron Viagene San Diego, CA	gene therapy	metastatic melanoma	Phase I
DA/Hu(gamma).15- transduced autologous tumor cells and interferon- gamma expressing transduced autologous tumor cells (combination therapy)	Chiron Viagene San Diego, CA	gene therapy	stage IV malignant melanoma	Phase I
DA/Hu(gamma).15- transduced autologous tumor cells; ITAT	Chiron Viagene San Diego, CA	gene therapy	disseminated malignant melanoma	Phase I
daniplestim	Searle Skokie, IL	growth factor	mobilization of peripheral blood stem cells	Phase III
dendritic cell therapy	Dendreon Mountain View, CA	cellular therapy	advanced prostate cancer	Phase IV/II
			multiple myeloma	Phase I
E/A lipid complex (tgDCC-E/A)	Targeted Genetics Seattle, WA	gene therapy	breast, head and neck, ovarian cancers	Phase I
ECF fusion protein DAB <sub>399</sub> ECF	Seragen Hopkinton, MA	fusion protein	non-small-cell lung cancer	Phase I/II
EPREX® erythropoietin	National Cancer Institute Bethesda, MD Ortho Biotech Raritan, NJ	erythropoietin	neuroblastoma	Phase II NCI TRIAL
ERB-38 immunotoxin fusion protein (recombinant)	National Cancer Institute Bethesda, MD	fusion protein	advanced stage solid tumors	Phase I NCI TRIAL
Ewing's sarcoma and alveolar rhabdomyosarcoma peptide vaccine	National Cancer Institute Bethesda, MD	vaccine	sarcoma	Phase I NCI TRIAL
FLT3 ligand	National Cancer Institute Bethesda, MD Immunex Seattle, WA	growth factor	melanoma, renal cell cancer	Phase I NCI TRIAL
G3139	Genta San Diego, CA	antisense	cancer	Phase I
gamma interferon gene therapy	Chiron Emeryville, CA	gene therapy	cancer	Phase I

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## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
Gastrimmune™ neutralizing G17 hormone	Aphron Woodland, CA	vaccine	colorectal, pancreatic, stomach cancers (see also digestive)	Phase VI
GeneVax® gene vaccine	Centocor Malvern, PA	vaccine	colorectal cancer	Phase I
GLI-328	Genetic Therapy Gaithersburg, MD	gene therapy	glioblastoma multiforme	Phase III
GM-CSF cellular cancer vaccine	Powderject Vaccines Madison, WI	vaccine	melanoma, sarcoma	Phase I
GMP ganglioside antigen	Bristol-Myers Squibb Princeton, NJ Progenics Pharmaceuticals Tarrytown, NY	vaccine	prevent recurrence following surgery to remove primary melanoma	Phase III
gp100 adenovirus vaccine	National Cancer Institute Bethesda, MD Genzyme Molecular Oncology Cambridge, MA	vaccine	melanoma	Phase I NCI TRIAL
gp100 peptide vaccine	National Cancer Institute Bethesda, MD	vaccine	melanoma	Phase I NCI TRIAL
GVAX™ cancer vaccine	Cell Genesys Foster City, CA	vaccine	prostate, lung cancers, melanoma	Phase VI
HER-2/neu peptide vaccine	National Cancer Institute Bethesda, MD	vaccine	breast, colorectal, ovarian, prostate cancers	Phase I NCI TRIAL
Herceptin™ trastuzumab (anti-HER-2 humanized MAb)	Genentech S. San Francisco, CA	MAb	breast cancer	Phase III completed
HPV 16, E6 and E7 peptide vaccine	National Cancer Institute Bethesda, MD	vaccine	cervical cancer	Phase I NCI TRIAL
HPV E7 lipopeptide vaccine	National Cancer Institute Bethesda, MD Cytel San Diego, CA	vaccine	cervical cancer	Phase I NCI TRIAL
HPV vaccine	MedImmune Gaithersburg, MD SmithKline Beecham Philadelphia, PA	vaccine	cervical cancer (see also infectious diseases)	Phase I
HSPPC-96 (autologous tumor derived)	Antigenics New York, NY	heat shock protein	melanoma, pancreatic, renal cell cancers	Phase I
human growth hormone	Transkaryotic Therapies Cambridge, MA	gene therapy	cancer cachexia (muscle wasting)	Phase I
IDEC-In88	IDEC Pharmaceuticals San Diego, CA	MAb	non-Hodgkin's B-cell lymphoma	Phase VII
IDEC-Y288	IDEC Pharmaceuticals San Diego, CA	MAb	non-Hodgkin's B-cell lymphoma	Phase VII

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TABLE A

## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
Leucotropin GM-CSF	Cangene Mississauga, Ontario	colony stimulating factor	mobilization of peripheral blood stem cells in patients with adjuvant breast cancer	Phase III
Leukine™ sargramostim (GM-CSF)	Immunex Seattle, WA	colony stimulating factor	prophylaxis and treatment of chemotherapy-induced neutropenia, prophylaxis of chemotherapy-induced neutropenia in acute myelogenous leukemia (see also AIDS/HIV)	application submitted
Leovectin DNA/lipid complex encoding IL-2	Vical San Diego, CA	gene therapy	prostate cancer, renal cell carcinoma, melanoma, sarcoma	Phase I
LP 2307	LIDAK Pharmaceuticals La Jolla, CA	vaccine	malignant melanoma	Phase I/II
LR-3001	Inex Pharmaceuticals Hayward, CA	antisense	chronic myelogenous leukemia in accelerated phase or blast crisis	Phase I
LYM-1	Techniclone Tustin, CA	MAB	lymphoma	Phase II/III
Lymphocide™ anti-CD22 humanized MAB	Immunomedics Morris Plains, NJ	MAB	non-Hodgkin's B-cell lymphoma	Phase I/II
LymphoScan™ technetium-99m- bectumomab (lymphoma)	Immunomedics Morris Plains, NJ	MAB	extent of disease staging of non-Hodgkin's B-cell lymphoma, detection of residual disease following radiation/chemotherapy	Phase III
MAB	Glaxo Wellcome Resch. Triangle Park, NC	MAB	lung, prostate cancers	Phase II
MART-1 adenovirus vaccine	National Cancer Institute Bethesda, MD Genzyme Molecular Oncology Cambridge, MA	vaccine	melanoma	Phase I NCI TRIAL
MART-1 melanoma vaccine	National Cancer Institute Bethesda, MD	vaccine	metastatic melanoma	Phase I NCI TRIAL
MDRx1™	Titan Pharmaceuticals S. San Francisco, CA	gene therapy	enable high-dose chemotherapy with reduced side effects	Phase I
MDX-447 bispecific antibody	Medarex Annandale, NJ	MAB	head and neck, renal cancers	Phase I/II
MDX-H210 bispecific antibody	Medarex Annandale, NJ	MAB	breast, colorectal, kidney, ovarian, prostate cancers	Phase I/II
Melacine® melanoma theraccine (therapeutic vaccine)	Ribi ImmunoChem Hamilton, MT	vaccine	stage IV melanoma with interferon alpha	Phase III completed
	Ribi ImmunoChem Hamilton, MT Southwest Oncology Group San Antonio, TX	vaccine	stage II melanoma in patients with no evidence of disease to prevent recurrence following surgery to remove primary disease	Phase III

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## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
myeloid progenitor inhibitory factor-1	Human Genome Sciences Rockville, MD	interleukin	chemoprotection	Phase I
myeloma-derived idiotypic antigen vaccine	National Cancer Institute Bethesda, MD	vaccine	multiple myeloma	Phase I NCI TRIAL
NEUPOGEN® Filgrastim (rG-CSF)	Amgen Thousand Oaks, CA	colony stimulating factor	acute myelogenous leukemia (see also AIDS/HIV, respiratory)	application submitted
Oncoaspar® PEG-L-asparaginase	Enzon Piscataway, NJ Rhône-Poulenc Rorer Titusville, NJ		first-line treatment of acute lymphoblastic leukemia (ALL) adult ALL, non-Hodgkin's lymphoma, chronic lymphocytic leukemia	in clinical trials
OncoIym®	Techniclone Tustin, CA	MAB	malignant glioma	Phase I
OncoRad® PR CYT-356-Y-90	CYTOGEN Princeton, NJ	MAB	targeted radiotherapy for prostate malignancies	Phase II
OncoScint® CR/OV satumomab pentetide	CYTOGEN Princeton, NJ	MAB	detection, staging and follow-up of breast cancer	Phase II
ONYX-015	Onyx Pharmaceuticals Richmond, CA	oncolytic virus therapy	p53 deficient cancers	Phase VII
p53 and RAS vaccine	National Cancer Institute Bethesda, MD	vaccine	solid tumors	Phase I NCI TRIAL
p53 tumor suppressor gene	Schering-Plough Madison, NJ	gene therapy	lung cancer	Phase II
			solid tumors that carry the p53 gene mutation or deletion	Phase I
Panorex® edrecolomab	Centocor Malvern, PA	MAB	adjuvant therapy for post-operative colorectal cancer	Phase III
peripheral blood lymphocytes transduced with a gene encoding a chimeric T-cell receptor	National Cancer Institute Bethesda, MD	gene therapy	ovarian cancer	Phase I NCI TRIAL
Proleukin® aldesleukin (interleukin-2)	Chiron Emeryville, CA	interleukin	acute myelogenous leukemia, non-Hodgkin's lymphoma (see also AIDS/HIV)	Phase I/III
promegapoietin	Searle Skokie, IL	growth factor	adjunctive hematopoietic therapy following chemotherapy	Phase I
Prostrac recombinant vaccinia virus	Therion Biologics Cambridge, MA	vaccine	prostate cancer	Phase VII

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TABLE A

## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
RAS 5-17 peptide vaccine	National Cancer Institute Bethesda, MD	vaccine	solid tumors	Phase I NCI TRIAL
rCEA Vaccine recombinant carcinoembryonic antigen	Protein Sciences Meriden, CT	vaccine	breast, colon cancers	Phase I
Rebif® recombinant Interferon beta-1a	Serono Laboratories Norwell, MA	interferon	colorectal cancer (see also infectious diseases, neurologic)	Phase III
			non-small-cell lung cancer	Phase I/II
recombinant human Interleukin-12 (rhIL-12)	Genetics Institute Cambridge, MA Wyeth-Ayerst Laboratories Philadelphia, PA	Interleukin	cancer (see also infectious diseases)	Phase I/II
retroviral vector with tumor necrosis factor gene	Chiron Emeryville, CA	gene therapy	melanoma	Phase I
rF-gp100 (recombinant fowlpox virus)	Therion Biologics Cambridge, MA	vaccine	melanoma	Phase I
rF-MART-1 (recombinant fowlpox virus)	Therion Biologics Cambridge, MA	vaccine	melanoma	Phase I
RIGScan® CR49 125 I-cc49 MAb	Neoprobe Dublin, OH	MAb	colorectal cancer	application submitted
Rituxan® rituximab	National Cancer Institute Bethesda, MD IDEC Pharmaceuticals San Diego, CA	MAB	leukemia, lymphoma	Phase II NCI TRIAL
Roferon®-A interferon alfa-2a, recombinant	Hoffmann-La Roche Nutley, NJ	interferon	malignant melanoma adjuvant	Phase III
rV-gp100 (recombinant vaccinia virus)	Therion Biologics Cambridge, MA	vaccine	melanoma	Phase I
rV-MART-1 (recombinant vaccinia virus)	Therion Biologics Cambridge, MA	vaccine	melanoma	Phase I
Serosifin™ somatropin (rDNA origin) for injection	Serono Laboratories Norwell, MA	human growth hormone	cancer cachexia (see also other)	Phase I/II
Sigolix® recombinant interleukin-6 (r-IL-6)	Ares-Serono and Serono Laboratories Norwell, MA	interleukin	hematological conditions (myelodysplastic syndromes, cancer)	Phase I/II

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TABLE A

## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
SMART™ M195 HuM195	Protein Design Labs Mountain View, CA	MAb	acute myeloid leukemia	Phase II/III
			acute promyelocytic leukemia	Phase II
			advanced myeloid leukemia (with Bismuth-213)	Phase I
stem cell factor	Amgen Thousand Oaks, CA	stem cell factor	adjunct to chemotherapy	application submitted
SU101	SUCEN Redwood City, CA	PDGF- receptor tyrosine kinase inhibitor	malignant glioma	Phase III
			prostate cancer	Phase II
			solid tumors	Phase I/II
SUS416	SUCEN Redwood City, CA	angiogenesis inhibitor	solid tumors	Phase I
TBC CEA (vaccinia virus expressing carcinoembryonic antigen)	Therion Biologics Cambridge, MA	vaccine	colorectal and lung cancers	Phase VII
TCell-HOM	Coulter Cellular Therapies Boston, MA	cellular therapy	cancer	Phase VII
Therapep® synthetic carbohydrate therapeutic vaccine	Biomira Edmonton, Alberta Chiron Emeryville, CA	vaccine	breast cancer	Phase II completed
thrombopoietin	Genentech S. San Francisco, CA	erythropoietin	thrombocytopenia related to cancer treatment	Phase II
Thyrogen® recombinant human thyroid-stimulating hormone	Genzyme Cambridge, MA		detection and treatment of thyroid cancer metastases	application submitted
TNT	Techniclone Tustin, CA	MAb	non-Hodgkin's B-cell lymphoma	Phase I/III
			solid tumors	Phase I
TriAB™ anti-idiotypic antibody vaccine	Titan Pharmaceuticals S. San Francisco, CA	vaccine	breast cancer	Phase II
TriGEM™ anti-idiotypic antibody vaccine	Titan Pharmaceuticals S. San Francisco, CA	vaccine	small-cell lung cancer, melanoma	Phase I
urate oxidase (recombinantly- produced enzyme)	Sanofi New York, NY	recombinant enzyme	prophylaxis for chemotherapy- related hyperuricemia, treatment of cancer-related hyperuricemia	Phase III

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TABLE A

## CANCER AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
vaccinia-CEA 180KD vaccine	National Cancer Institute Bethesda, MD Therion Biologics Cambridge, MA	vaccine	advanced colorectal cancer	Phase I NCI TRIAL
Vaxid anti-idiotypic DNA vaccine	Vical San Diego, CA	vaccine	B-cell and mantle cell lymphomas	Phase I
Xerecept <sup>TM</sup> human corticotropin-releasing factor (hCRF)	Neurobiological Technologies Richmond, CA		brain tumor edema	Phase II
Zenapax <sup>®</sup> daclizumab	Hoffmann-La Roche Nutley, NJ Protein Design Labs Mountain View, CA	MAb	certain blood cancers (see also eye, neurologic, skin, transplantation)	Phase II

## DIABETES AND RELATED CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
Beta Kine transforming growth factor-beta 2	Genzyme Tissue Repair Cambridge, MA	growth factor	chronic diabetic foot ulcers	Phase II
BetaRx-H encapsulated human islets	VivoRx Santa Monica, CA	cellular therapy	insulin-dependent diabetes	Phase I
BetaRx-P encapsulated porcine islets	VivoRx Santa Monica, CA	cellular therapy	insulin-dependent diabetes	Phase I
BetaRx-Pr encapsulated proliferated human islets	VivoRx Santa Monica, CA	cellular therapy	insulin-dependent diabetes	Phase I
Glucagen <sup>TM</sup> recombinant human glucagon (protein)	Novo Nordisk Pharmaceuticals Princeton, NJ	recombinant human protein	hypoglycemia (see also digestive)	Phase III
glucagon for injection (rDNA origin)	Eli Lilly Indianapolis, IN	recombinant human protein	to treat severe hypoglycemic events in patients with diabetes and to aid in gastrointestinal diagnostic procedures	application submitted
insulinotropin	Scios Mountain View, CA		type 2 diabetes	Phase II
memantine	Neurobiological Technologies Richmond, CA		painful diabetic neuropathy (see also AIDS/HIV)	Phase II
nerve growth factor	Genentech S. San Francisco, CA	growth factor	diabetic peripheral neuropathy	Phase III

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**DIABETES AND RELATED CONDITIONS**

Product Name	Company	Product Category	Indication	Development Status
pimagedine	Aleon Ramsey, NJ Genentech S. San Francisco, CA		diabetic progressive kidney disease, diabetic end-stage kidney disease (see also neurologic)	Phase III
pramlintide	Amylin Pharmaceuticals San Diego, CA	human amylin analog	improved metabolic control, which includes glucose, weight and lipid profiles in type 1 and insulin-using type 2 diabetes	Phase III
rDNA insulin	Inhale Therapeutic Systems Palo Alto, CA	recombinant insulin	diabetes	Phase II
Trovert™	Sensus Austin, TX	human growth hormone	diabetes-related illnesses (see also growth disorders)	Phase II

**DIGESTIVE DISORDERS**

Product Name	Company	Product Category	Indication	Development Status
Avakine™ chimeric anti-TNF antibody	Centocor Malvern, PA	MAB	Crohn's disease (see also autoimmune)	application submitted
Gastrimmune™ neutralizing G17 hormone	Aphron Woodland, CA	vaccine	gastroesophageal reflux disease, peptic and nonsteroidal anti-inflammatory drug ulcers (see also cancer)	Phase I/II
Glucagon™ recombinant human glucagon (protein)	Novo Nordisk Pharmaceuticals Princeton, NJ	recombinant human protein	gastrointestinal motility inhibition (see also diabetes)	Phase III
interleukin-10 (IL-10)	Schering-Plough Madison, NJ	interleukin	Crohn's disease, ulcerative colitis (see also AIDS/HIV, autoimmune, heart, neurologic, respiratory, skin)	Phase II
ISIS 2302	Isis Pharmaceuticals Carlsbad, CA	antisense	Crohn's disease, ulcerative colitis (see also autoimmune, skin, transplantation)	Phase II
LDP-02	Genentech S. San Francisco, CA LeukoSite Cambridge, MA	MAB	inflammatory bowel disease	Phase II
LeukoScan® sulesomab	Immunomedics Morris Plains, NJ	MAB	inflammatory bowel disease (see also infectious diseases)	Phase II
Neumega® recombinant human interleukin-11	Genetics Institute Cambridge, MA	interleukin	Crohn's disease	Phase II
recombinant platelet activating factor- acetylhydrolase (rPAF-AH)	ICOS Bohemia, WA		pancreatitis (see also respiratory)	Phase II

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TABLE A

## EYE CONDITIONS

Product Name	Company	Product Category	Indication	Development Status
BPD-MA verteporfin	QLT PhotoTherapeutics Vancouver, British Columbia		age-related macular degeneration	Phase III
MDX-RA immunotoxin	Medarex Annandale, NJ	MAb	prevention of secondary cataract	Phase III
Zenapax® dalcizumab	Hoffmann-La Roche Nutley, NJ Protein Design Labs Mountain View, CA	MAb	uveitis (see also cancer, neurologic, skin, transplantation)	Phase VI

## GENETIC DISORDERS

Product Name	Company	Product Category	Indication	Development Status
AAV CFTR gene therapy	Targeted Genetics Seattle, WA	gene therapy	cystic fibrosis (see also respiratory)	Phase I
CFTR/adenovirus vector	Genzyme Cambridge, MA	gene therapy	cystic fibrosis	Phase I
CFTR/lipid vector	Genzyme Cambridge, MA	gene therapy	cystic fibrosis	Phase I
ex vivo stem cells/ retrovirus vector	Genzyme Cambridge, MA	gene therapy	Gaucher's disease	Phase I
GR213487B	Glaxo Wellcome Rsch. Triangle Park, NC Megabios Burlingame, CA	gene therapy	cystic fibrosis	Phase VII
GV-10	GenVec Rockville, MD	gene therapy	cystic fibrosis	Phase I
HP-3	Milkhaus Laboratory Buxford, MA	signalling	cystic fibrosis	Phase II
Neuprex™ recombinant human bactericidal/ permeability- increasing protein (rBPI-21)	XOMA Berkeley, CA	recombinant human protein	cystic fibrosis exacerbations (see also infectious diseases, other)	Phase I
Pulmozyme® dornase alpha, recombinant	Genentech S. San Francisco, CA	recombinant DNase	early intervention in cystic fibrosis	Phase III
x-galactosidase A	Transkaryotic Therapies Cambridge, MA	enzyme	Fabry's disease	Phase I

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**GROWTH DISORDERS**

Product Name	Company	Product Category	Indication	Development Status
pralmorelin (CPA-748)	Wyeth-Ayerst Laboratories Philadelphia, PA	human growth hormone	adult growth hormone deficiency	Phase I
ProLease® hGH	Alkermes Cambridge, MA Genentech S. San Francisco, CA	human growth hormone	growth hormone deficiency in children	Phase III
Saizen® somatotropin (rDNA origin) for injection	Serono Laboratories Norwell, MA	human growth hormone	management of adults with growth hormone disorder, intrauterine growth retardation in children (see also other)	Phase III
Trovert™	Sensus Austin, TX	human growth hormone	acromegaly (see also diabetes)	Phase II

**HEART DISEASE**

Product Name	Company	Product Category	Indication	Development Status
AcuTect™ Tc-99m apcitide	Diatide Londonderry, NH	peptide	detection of carotid thrombus	Phase II
anti-CD18 humanized MAb	Genentech S. San Francisco, CA	MAb	acute myocardial infarction	Phase II
BioByPass™ therapeutic angiogenesis (VEGF)	GenVec Rockville, MD	gene therapy	cardiovascular disease, including cardiac artery disease and peripheral vascular disease, either as an adjunct or alternative to existing surgical approaches such as cardiac artery bypass grafts and angioplasty	Phase I
BioStent™	NeoRx Seattle, WA		reduction of restenosis (vascular remodeling) following balloon angioplasty	Phase I
Capiscint	Centocor Malvern, PA	MAb	atherosclerotic plaque imaging agent	Phase I
Corsevin™ M 12D10-Fab	Centocor Malvern, PA Corvas San Diego, CA	MAb	thrombolytic complications of percutaneous transluminal coronary angioplasty, coronary arterial stents, disseminates intravascular coagulation	Phase I
CPC-111	Cypros Pharmaceuticals Carlsbad, CA	cellular therapy	coronary bypass surgery (see also blood)	Phase II
factor VIIa inhibitors	Corvas San Diego, CA		deep vein thrombosis, pulmonary embolism, unstable angina, myocardial infarction	Phase I
FIBLAST® braferrin	Scios Mountain View, CA Wyeth-Ayerst Laboratories Philadelphia, PA	growth factor	peripheral vascular disease, coronary artery disease (see also neurologic)	Phase II

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TABLE A

## HEART DISEASE

Product Name	Company	Product Category	Indication	Development Status
gene therapy	Collateral Therapeutics San Diego, CA	gene therapy	stable exertional angina	Phase I/II
growth factor	Chiron Emeryville, CA	growth factor	coronary artery disease	Phase I
hSC1.1-SCFV (recombinant)	Alexion Pharmaceuticals New Haven, CT Enzon Piscataway, NJ		cardiopulmonary bypass-associated inflammation using SCD® technology	Phase II
Hu23F2G MAb	ICOS Bothell, WA	MAb	myocardial infarction (see also neurologic, other)	Phase II
Integrilin™ eptifibatide (IIb/IIIa platelet aggregation inhibitor)	COR Therapeutics S. San Francisco, CA Schering-Plough Madison, NJ		percutaneous transluminal coronary angioplasty, unstable angina	application submitted
			acute myocardial infarction	Phase II
Interleukin-10 (IL-10)	Schering-Plough Madison, NJ	interleukin	ischemic reperfusion injury (see also AIDS/HIV, autoimmune, digestive, neurologic, respiratory, skin)	Phase I
Ianoreplase	Bristol-Myers Squibb Princeton, NJ	t-PA	acute myocardial infarction	Phase III
LR-3280	Inex Pharmaceuticals Vancouver, BC Schwarz Pharma Milwaukee, WI	antisense	cardiovascular restenosis	Phase II
MH1-Fab* imaging agent	American Biogenetic Sciences Boston, MA	MAb	in vivo imaging agent for the detection of cardiovascular thrombosis	Phase I/II
MPL®-C immunomodulator	Ribi ImmunoChem Hamilton, MT		prevention/amelioration of cardiac ischemia reperfusion injury	Phase II
Natrecor® BNP	Scios Mountain View, CA		acute congestive heart failure	Phase III completed/ application submitted
			cardiovascular pulmonary surgery	Phase I
Novastan® argatroban	Texas Biotechnology Houston, TX		heparin-induced thrombocytopenia thrombosis syndrome	application submitted
ReoPro® abciximab	Centocor Malvern, PA Eli Lilly Indianapolis, IN	MAb	unstable angina (see also neurologic)	Phase III
			acute myocardial infarction	Phase II
rhAntithrombin III (recombinant)	Genzyme Cambridge, MA		control of blood clotting during coronary artery bypass surgery	Phase II completed
TNK (second-generation t-PA)	Genentech S. San Francisco, CA	t-PA	acute myocardial infarction	Phase III

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TABLE A

## HEART DISEASE

Product Name	Company	Product Category	Indication	Development Status
TP10	T Cell Sciences Needham, MA	recombinant soluble receptor	heart attack (see also respiratory, transplantation)	Phase I
VEGF	Genentech S. San Francisco, CA	growth factor	coronary artery disease	Phase I
VEGF 121 (vascular endothelial growth factor)	Scios Mountain View, CA	growth factor	cardiovascular disorders	Phase I
Xubix™ sibitraban oral IIb/IIIa antagonist	Genentech S. San Francisco, CA		acute coronary syndrome	Phase III

## INFECTIOUS DISEASES

Product Name	Company	Product Category	Indication	Development Status
adefovir dipivoxil	Gilead Sciences Foster City, CA	nucleotide analogue	hepatitis B	Phase II
Alferon N Gel® interferon alfa-n3	Interferon Sciences New Brunswick, NJ	interferon	human papillomavirus infections	Phase II
Alferon N Injection® interferon alfa-n3	Interferon Sciences New Brunswick, NJ	interferon	chronic hepatitis C infections (see also AIDS/HIV)	Phase III
			genital warts	Phase II
Ampligen®	Hemisphere Biopharma New York, NY	interferon	hepatitis (see also AIDS/HIV, cancer, other)	Phase VII
anti-tumor necrosis factor MAb	Chiron Emeryville, CA	MAb	sepsis	Phase I/II
Campylobacter vaccine	Antex Biologics Gaithersburg, MD	cellular vaccine	traveler's diarrhea (Campylobacter infections)	Phase II
CMV vaccine	Chiron Emeryville, CA	vaccine	cytomegalovirus infection	Phase II
DTaP vaccine	Chiron Emeryville, CA	vaccine	diphtheria, tetanus, acellular pertussis	Phase III
Epstein-Barr virus vaccine	Aviron Mountain View, CA SmithKline Beecham Philadelphia, PA	recombinant subunit vaccine	prevention of Epstein-Barr virus infection (cause of mononucleosis infection)	Phase I
genital herpes vaccine	Glaxo Wellcome Rsch. Triangle Park, NC	vaccine	genital herpes	Phase I
Helicobacter vaccine	Antex Biologics Gaithersburg, MD	cellular vaccine	peptic ulcers (Helicobacter pylori infections)	Phase I

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## INFECTIOUS DISEASES

Product Name	Company	Product Category	Indication	Development Status
hepatitis A vaccine	Chiron Emeryville, CA	vaccine	hepatitis A	Phase III
hepatitis B DNA vaccine	Powderject Vaccines Madison, WI	DNA vaccine	hepatitis B prevention	Phase I
hepatitis B vaccine (recombinant)	SmithKline Beecham Philadelphia, PA	vaccine	treatment of hepatitis B	Phase II
herpes simplex vaccine (recombinant)	SmithKline Beecham Philadelphia, PA	vaccine	prevention of herpes simplex infection	Phase III
HPV vaccine	MedImmune Gaithersburg, MD SmithKline Beecham Philadelphia, PA	vaccine	genital warts (see also cancer)	Phase I
human anti-hepatitis B antibody (OST 577)	Protein Design Labs Mountain View, CA	MAB	liver transplantation due to chronic hepatitis B infection	Phase I/II completed
Intron® A interferon alfa-2b (recombinant)	Schering-Plough Madison, NJ	interferon	pediatric hepatitis B, self-injectable dosing system for hepatitis C (see also cancer)	application submitted
			hepatitis C (PEG-Intron A)	Phase III
Intron® A/ Rebetol™ interferon alfa-2b (recombinant)/ ribavirin	Schering-Plough Madison, NJ	interferon	relapsed hepatitis C	application submitted
			naive hepatitis C (not previously treated with interferon)	Phase III
			hepatitis C (PEG-Intron A/Rebetol)	Phase I
LeukoScan® sulesomab	Immunomedics Morris Plains, NJ	MAB	diagnosis of osteomyelitis, infected prosthesis, appendicitis (see also digestive)	application submitted
Lyme borreliosis protein vaccine	Pasteur Merieux Connaught Swiftwater, PA	vaccine	Lyme disease	Phase III
Lyme disease vaccine (recombinant)	SmithKline Beecham Philadelphia, PA	vaccine	prevention of Lyme disease	application submitted
MAK 195F	Knoll Pharmaceutical Mt. Olive, NJ	MAB	sepsis	Phase III
MEDI-491 parvovirus B 19 vaccine	MedImmune Gaithersburg, MD	vaccine	B 19 parvovirus-induced miscarriages and anemia	Phase I
meningococcus C vaccine	Chiron Emeryville, CA	vaccine	meningococcus C	Phase II

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## INFECTIOUS DISEASES

Product Name	Company	Product Category	Indication	Development Status
MPL® immunomodulator (25+ antigens for adult and pediatric applications)	Ribi ImmunoChem Hamilton, MT	vaccine	infectious diseases (see also AIDS/HIV)	in clinical trials
Neuprex™ recombinant human bactericidal/ permeability- increasing protein (rBP-21)	XOMA Berkeley, CA	recombinant human protein	meningococemia (see also genetic, other)	Phase III
			antibiotic adjuvant in intra-abdominal infections	Phase II
Proteovir™ human anti-CMV antibody	Protein Design Labs Mountain View, CA	MAB	cytomegalovirus infections in bone marrow transplant patients	Phase II completed
Relip® recombinant interferon beta-1a	Serono Laboratories Norwell, MA	interferon	viral infections (see also cancer, neurologic)	Phase II/III
recombinant human activated protein C (rhAPC)	Eli Lilly Indianapolis, IN	recombinant human protein	treatment of severe sepsis	Phase II
recombinant human interleukin-12 (rhIL-12)	Genetics Institute Cambridge, MA Wyeth-Ayerst Laboratories Philadelphia, PA	interleukin	infectious diseases (see also cancer)	Phase I/II
Rotashield™ rotavirus vaccine, live, oral, tetra-valent	Wyeth-Lederle Vaccines & Pediatrics Philadelphia, PA	continuous cell line vaccine	prevention of rotaviral gastroenteritis in infants	application submitted
rotavirus vaccine	Virus Research Institute Cambridge, MA	vaccine	rotavirus in infants	Phase II
Savvy™ C31G	Biosyn Philadelphia, PA	microbicide	infectious disease	Phase I
Tenetus® lenercept (TNF-receptor fusion protein)	Hoffmann-La Roche Nutley, NJ	recombinant soluble receptor	septic shock, severe sepsis	Phase III
tifacogin	Chiron Emeryville, CA Searle Skokie, IL	tissue factor pathway inhibitor	sepsis	Phase II

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## INFERTILITY

Product Name	Company	Product Category	Indication	Development Status
Aaside™ gonadotropin hormone-releasing hormone antagonist (GhRHA)	Ares-Serono and Serono Laboratories Norwell, MA	hormone- releasing hormone antagonist	female infertility	Phase I
Gonal-P® recombinant human follicle-stimulating hormone (r-FSH)	Serono Laboratories Norwell, MA	recombinant fertility hormone	male infertility	Phase III
LhAD® recombinant human luteinizing hormone (r-hLH)	Ares-Serono and Serono Laboratories Norwell, MA	recombinant fertility hormone	female infertility—follicular support, stimulation of follicular development	Phase IV/III
Ovidrel® recombinant human chorionic gonadotropin (r-hCG)	Ares-Serono and Serono Laboratories Norwell, MA	recombinant gonadotropin	female infertility (see also AIDS/HIV)	Phase III

## NEUROLOGIC DISORDERS

Product Name	Company	Product Category	Indication	Development Status
Activase® alteplase, recombinant	Genentech S. San Francisco, CA	t-PA	acute ischemic stroke within 3 to 5 hours of symptom onset	Phase III
Anergix™MS	Anengen Redwood City, CA	functional antigenics immuno- therapy	multiple sclerosis	Phase I
Antegren natalizumab	Athena Neurosciences S. San Francisco, CA	MAb	multiple sclerosis flares	Phase II
ATM027 humanized MAb	T Cell Sciences Needham, MA	MAb	multiple sclerosis	Phase I
Avonex® interferon beta-1a	Biogen Cambridge, MA	interferon	secondary, progressive multiple sclerosis (see also cancer)	Phase III
Betaseron® recombinant interferon beta-1b	Berlex Laboratories Wayne, NJ Chiron Emeryville, CA	interferon	chronic progressive multiple sclerosis (see also cancer)	Phase III
brain-derived neurotrophic factor (BDNF)	Amgen Thousand Oaks, CA Regeneron Pharmaceuticals Tarrytown, NY	growth factor	amyotrophic lateral sclerosis	Phase I

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## NEUROLOGIC DISORDERS

Product Name	Company	Product Category	Indication	Development Status
CPC-211	Cypros Pharmaceuticals Carlsbad, CA	cellular therapy	ischemic stroke, traumatic brain injury	Phase II
enlimomab (anti-ICAM-1 MAb)	Boehringer Ingelheim Pharmaceuticals Ridgefield, CT	MAb	stroke (see also other)	Phase II/III
FIBLAST® trafermin	Scios Mountain View, CA Wyeth-Ayerst Laboratories Philadelphia, PA	growth factor	stroke (see also heart)	Phase IV/III
Hu23F2G MAb	ICOS Bothell, WA	MAb	multiple sclerosis, ischemic stroke (see also heart, other)	Phase II
interleukin-10 (IL-10)	Schering-Plough Madison, NJ	interleukin	multiple sclerosis (see also AIDS/HIV, autoimmune, digestive, heart, respiratory, skin)	Phase I
IR 208 therapeutic vaccine	Immune Response Corp. Carlsbad, CA	vaccine	multiple sclerosis	Phase I
LDP-01	LeukoSite Cambridge, MA	MAb	stroke (see also transplantation)	Phase VII
MS-TCR	Connetics Palo Alto, CA	vaccine	multiple sclerosis	Phase VII
Myotrophin® rhIGF-1	Cephalon West Chester, PA Chiron Emeryville, CA	growth factor	amyotrophic lateral sclerosis peripheral neuropathies	application submitted Phase II
NeuroCell™-FE (cellular transplantation therapy)	Diacrin Charlestown, MA	cellular therapy	focal epilepsy	Phase I
NeuroCell™-HD (cellular transplantation therapy)	Diacrin Charlestown, MA Genzyme Tissue Repair Cambridge, MA	cellular therapy	Huntington's disease	Phase I completed
NeuroCell™-PD (cellular transplantation therapy)	Diacrin Charlestown, MA Genzyme Tissue Repair Cambridge, MA	cellular therapy	Parkinson's disease	Phase II
neurotrophin-3	Amgen Thousand Oaks, CA Regeneron Pharmaceuticals Tarrytown, NY	growth factor	enteric neuropathies	Phase I/II
pimagedine	Alkion Ramsey, NJ Genentech S. San Francisco, CA		overt neuropathy (see also diabetes)	Phase III
prosaptide TX14(A)	Myelos Neurosciences San Diego, CA	growth factor	neuropathic pain and peripheral neuropathy	Phase II

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## NEUROLOGIC DISORDERS

Product Name	Company	Product Category	Indication	Development Status
Rebif® recombinant Interferon beta-1a	Serono Laboratories Norwell, MA	Interferon	relapsing, remitting multiple sclerosis; transitional multiple sclerosis (see also cancer, infectious diseases)	application submitted
ReoPro® abciximab	Centocor Malvern, PA Eli Lilly Indianapolis, IN	MAB	stroke (see also heart)	Phase II
Spheramine™	Titan Pharmaceuticals S. San Francisco, CA	cellular therapy	Parkinson's disease	Phase I
Zenapax® dacizumab	Hoffmann-La Roche Nutley, NJ Protein Design Labs Mountain View, CA	MAB	tropical spastic paraparesis (model for multiple sclerosis) (see also cancer, eye, skin, transplantation)	Phase I/II

## RESPIRATORY DISEASES

Product Name	Company	Product Category	Indication	Development Status
AAV CFTR gene therapy	Targeted Genetics Seattle, WA	gene therapy	sinusitis (see also genetic)	Phase I
acellular pertussis vaccine	Chiron Emeryville, CA	vaccine	pediatric pertussis (whooping cough)	application submitted
anti-IgE humanized MAB	Genentech S. San Francisco, CA Novartis Pharmaceuticals East Hanover, NJ Tanox Biosystems Houston, TX	MAB	allergic asthma  allergic rhinitis	Phase III  Phase II
Influenza rHAO Vaccine influenza vaccine	Protein Sciences Meriden, CT	vaccine	prevention of influenza	Phase II
influenza virus vaccine (live, attenuated)	Aviron Mountain View, CA	vaccine	prevention of influenza	Phase I/II
interleukin-4 receptor	Immunex Seattle, WA	recombinant soluble receptor	asthma	Phase I
interleukin-10 (IL-10)	Schering-Plough Madison, NJ	interleukin	acute lung injury (see also AIDS/HIV, autoimmune, digestive, heart, neurologic, skin)	Phase I
lisofylline	Cell Therapeutics Seattle, WA		acute lung injury (see also other)	Phase II
NEUPOGEN® Filgrastim (rG-CSF)	Amgen Thousand Oaks, CA	colony stimulating factor	multilobar pneumonia, pneumonia sepsis (see also AIDS/HIV, cancer)	Phase III

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## RESPIRATORY DISEASES

Product Name	Company	Product Category	Indication	Development Status
Oxodrol® rhCu2r super dismutase	Bio-Technology General Iselin, NJ	dismutase	bronchopulmonary dysplasia in premature infants	Phase III
parainfluenza type-3 vaccine (live, attenuated bovine)	Aviron Mountain View, CA	vaccine	prevention of parainfluenza type-3 infection (cause of croup in infants)	Phase II
PIV vaccine, live, attenuated	Wyeth-Lederle Vaccines & Pediatrics Philadelphia, PA	continuous cell line vaccine	prevention of parainfluenza virus-mediated lower respiratory disease in infants	Phase I
Quilimmune-P	Aquila Biopharmaceuticals Worcester, MA	vaccine	pneumococcal infections in the elderly	Phase II
recombinant platelet activating factor- acetylhydrolase (rPAF-AH)	ICOS Bothell, WA		acute respiratory distress syndrome, asthma (see also digestive)	Phase II
RSV subunit vaccine	Wyeth-Lederle Vaccines & Pediatrics Philadelphia, PA	continuous cell line vaccine	prevention of respiratory syncytial virus-mediated lower respiratory disease in the elderly and at-risk children	Phase II
RSV vaccine, live, attenuated	Wyeth-Lederle Vaccines & Pediatrics Philadelphia, PA	continuous cell line vaccine	prevention of respiratory syncytial virus-mediated lower respiratory disease in infants	Phase I
soluble ICAM-1 (BIRRA)	Boehringer Ingelheim Pharmaceuticals Ridgefield, CT	recombinant soluble receptor	prevention and/or treatment of rhinovirus-induced common cold	Phase II
Synagis™ MEDI-493 humanized RSV MAb	Medimmune Gaithersburg, MD	MAb	prevention of respiratory syncytial virus disease	application submitted
TP10	T Cell Sciences Needham, MA	recombinant soluble receptor	acute respiratory distress syndrome (see also heart, transplantation)	Phase II
truncated ICAM	Bayer Berkeley, CA	adhesion molecule	rhinovirus-associated exacerbations of asthma	Phase I

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## SKIN DISORDERS

Product Name	Company	Product Category	Indication	Development Status
anti-CD11a humanized MAb (hu1124)	Genentech S. San Francisco, CA XOMA Berkeley, CA	MAb	moderate to severe psoriasis	Phase II
gamma interferon	Connetics Palo Alto, CA	interferon	keloids	Phase II
ICM3	ICOS Bothell, WA	MAb	psoriasis	Phase I
IL-2 fusion protein DAB <sub>389</sub> IL-2	Seragen Hopkinton, MA	fusion protein	moderate to severe psoriasis (see also autoimmune, cancer)	Phase III
interleukin-10 (IL-10)	Schering-Plough Madison, NJ	interleukin	psoriasis (see also AIDS/HIV, autoimmune, digestive, heart, neurologic, respiratory)	Phase I
IR 502 therapeutic vaccine	Immune Response Corp. Carlsbad, CA	vaccine	psoriasis	Phase II
ISIS 2302	Isis Pharmaceuticals Carlsbad, CA	antisense	psoriasis (see also autoimmune, digestive, transplantation)	Phase II
keratinocyte growth factor-2 (KGF-2)	Human Genome Sciences Rockville, MD	growth factor	wound healing (see also other)	Phase I
LFA3TIP	Biogen Cambridge, MA	recombinant T-cell inhibitor	psoriasis	Phase II
Regranex™ becaplermin (recombinant human platelet-derived growth factor-BB)	Chiron Emeryville, CA R.W. Johnson Pharmaceutical Research Institute Raritan, NJ	growth factor	pressure ulcers (see also other)	Phase III
T4N5 Liposome Lotion T4 endonuclease V encapsulated in liposomes	Applied Genetics Freeport, NY		protection against actinic keratoses in patients with xeroderma pigmentosa	Phase III
TGF-beta3	OSI Pharmaceuticals Uniondale, NY	growth factor	impaired wound healing (see also other)	Phase II
transforming growth factor-beta-3	Novartis Pharmaceuticals East Hanover, NJ	growth factor	wound healing	Phase II
Zenapax® dactizumab	Hoffmann-La Roche Nutley, NJ Protein Design Labs Mountain View, CA	MAb	psoriasis (see also cancer, eye, neurologic, transplantation)	Phase I/II

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## TRANSPLANTATION

Product Name	Company	Product Category	Indication	Development Status
allogeneic hematopoietic stem cells	SyStemix Palo Alto, CA	cellular therapy	correct genetic diseases by in utero transplantation of genetically unaffected cells from a sibling or parent	Phase I
CBL antibody (ABX-CBL)	Abgenix Foster City, CA	MAB	graft versus host disease	Phase II
CTLA4Ig	Bristol-Myers Squibb Princeton, NJ	recombinant soluble receptor	immunosuppression	Phase II
HSD-Tk retroviral vector	Genetic Therapy Gaithersburg, MD SyStemix Palo Alto, CA	gene therapy	treatment of graft versus host disease in allogeneic hematopoietic stem cell transplantation	Phase I
HSV-tk	Chiron Emeryville, CA	gene therapy	graft versus host disease in bone marrow transplantation	Phase I
ISIS 2302	Isis Pharmaceuticals Carlsbad, CA	antisense	renal transplant rejection (see also autoimmune, digestive, skin)	Phase II
LDP-01	LeukoSite Cambridge, MA	MAB	kidney transplantation (see also neurologic)	Phase I/II
MEDI-507 (humanized MAB)	Medimmune Gaithersburg, MD BioTransplant Charlestown, MA	MAB	graft versus host disease acute kidney transplant rejection	Phase II Phase I/II
ORTHOCLONE OKT4A	Ortho Biotech Raritan, NJ	MAB	prevention of organ transplant rejection (see also autoimmune)	Phase II
Simlect basiliximab	Novartis Pharmaceuticals East Hanover, NJ	MAB	transplantation	application submitted
SMART™ Anti-CD3 HuM291	Protein Design Labs Mountain View, CA	MAB	organ transplantation (see also autoimmune)	Phase I
TP10	T Cell Sciences Needham, MA	recombinant soluble receptor	transplantation (see also heart, respiratory)	Phase I/II
Zenapax® daclizumab	Hoffmann-La Roche Nutley, NJ Protein Design Labs Mountain View, CA	MAB	liver transplantation (see also cancer, eye, neurologic, skin) pediatric kidney transplantation	Phase II Phase I/II
Zenapax® daclizumab and Cellcept®	Hoffmann-La Roche Nutley, NJ Protein Design Labs Mountain View, CA	MAB	kidney transplant rejection, cyclosporine elimination	Phase I/II

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## OTHER

Product Name	Company	Product Category	Indication	Development Status
Recombunin recombinant human albumin	Centzon King of Prussia, PA		excipient use	Phase I
Regranex™ becaplermin (recombinant human platelet-derived growth factor-BB)	Chiron Emeryville, CA R.W. Johnson Pharmaceutical Research Institute Raritan, NJ	growth factor	venous ulcers (see also skin)	Phase III
rhBMP-2	Genetics Institute Cambridge, MA	growth factor	bone and cartilage repair	in clinical trials
Seizen® somatotropin (rDNA origin) for injection	Serono Laboratories Norwell, MA	human growth hormone	chronic renal failure in children (see also growth disorders)	Phase III
			post-operative recovery	Phase II
Serosist™ somatotropin (rDNA origin) for injection	Serono Laboratories Norwell, MA	human growth hormone	metabolic conditions (see also cancer)	Phase II
Somatoline® recombinant insulin-like growth factor-I/ binding protein-3	Celtrix Pharmaceuticals Santa Clara, CA	growth factor	hip fractures, severe acute burns	Phase II
TCF-beta3	OSI Pharmaceuticals Uniondale, NY	growth factor	oral mucositis (see also skin)	Phase II

The content of this survey has been obtained through government and industry sources based on the latest information. Survey current as of March 13, 1998. The information may not be comprehensive. For more specific information about a particular product, contact the individual company directly.

PhRMA Internet address: <http://www.phrma.org>

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In one aspect, particular benefit is obtained with this invention when used with biopharmaceuticals, which include, for example, any proteins, polypeptides, enzymes, immunoglobulins, polynucleic acids, and plasmids or other biopolymers. Specific examples of biopharmaceuticals to be included in the crystal formulations of the present invention include the following: insulin, glucagon, Glucagon-Like Peptide-1 (7-37)OH (GLP-1), human growth hormone, leptin, follicle-stimulating hormone (FSH), ribozyme, and analogs thereof.

The API's useful with the present invention include those which themselves may form crystalline products, as well as those which do not. By way of example, any proteins can be prepared as microcrystalline suspension products, but the results have frequently been unsatisfactory using existing technology. However, inclusion of these biomolecules into a host crystal system in accordance with the present invention overcomes this limitation on crystallization. The invention further finds utility even with API's that are readily crystallized, such as insulin. The incorporation of such API's into a single crystal lattice can be used to enhance stability or provide means of delivery that have different characteristics.

Solvents for preparation of the saturated and supersaturated crystal lattice component include, but are not limited to, water, alcohols (e.g., ethanol, isopropanol), other organic solvents, acids, bases, and buffers.

The crystals of the present invention are prepared to have a predetermined amount of active pharmaceutical ingredient. The desired amount of active pharmaceutical ingredient will depend on typical considerations, such as the effective amount of API used for administering to a patient. The concentration of API in the crystal is controlled, such as by previously described means, to yield crystals which are readily used in preparing pharmaceutical formulations for administration. The active pharmaceutical ingredient can be incorporated into the crystals at any of a wide variety of molar or weight percentages. Preferred percentages can be easily selected by a skilled artisan taking into account the usual considerations for later formulation of the desired pharmaceutical compositions, depending on the application, route of delivery, and desired pharmacological profile. Preferred percentages include, for example, concentrations of 0.01 - 1 weight percent. As used herein, all weight percentages are given as the percent

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based on the weight of the crystal including the crystal lattice component, the active pharmaceutical ingredient and any other components included within the crystals, unless stated otherwise.

The crystals may be prepared at varying size distributions, similarly  
5 depending on the subsequent formulating to be done with the crystals, or on crystal growth parameters. The crystals may be harvested and then sorted directly to desired size ranges, or may first be processed, such as by grinding or milling, and then sorted such as by sieving. As will be appreciated, a desired amount of active pharmaceutical ingredient may be obtained simply by obtaining a determined  
10 weight of crystals containing the active pharmaceutical ingredient at a known weight concentration. The useful size or weight range of the crystals of the present invention accordingly varies widely, depending on such factors as the inclusion level of the active pharmaceutical ingredient, the dosage amount for the active pharmaceutical ingredient, and the method of delivery of the crystals. By way of  
15 example, suitable crystals may have an average size distribution of 1  $\mu\text{m}$  to 1 mm.

The crystals of the present invention will typically be used in a formulation comprising a large number of crystals. It is a feature of the present invention that the active pharmaceutical ingredient is included within the crystal lattice component in a predictable, oriented fashion. This leads to a uniform  
20 concentration of the active pharmaceutical ingredient as a molar, and therefore weight, percentage of the crystals. In one aspect of the present invention, there is provided a composition of crystals having a substantially uniform weight concentration of active pharmaceutical ingredient as between crystals. The term  
25 "substantially uniform weight concentration" refers to the fact that the weight concentration of active pharmaceutical ingredient in the various crystals is sufficiently uniform that an acceptably accurate weight of active pharmaceutical ingredient can be obtained based on the weight of the crystals and the average concentration of active pharmaceutical ingredient in such crystals. In one preferred embodiment, there is provided a composition of crystals in which the size  
30 distribution of active pharmaceutical ingredient does not vary between crystals by more than about 20 percent. However, alternate embodiments may be equally

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useful, including mixtures of different size crystals. A desired quantity of active pharmaceutical ingredient is then accurately obtained by measuring a weight amount of crystals which, given the concentration of active pharmaceutical ingredient, yields the selected weight of active pharmaceutical ingredient.

5           The crystals and included API's are useful in the crystal form for both the stabilization and storage of the API and for the administration of the API to a patient. As used herein, it will be appreciated that the term patient refers to either humans or non-humans, depending on the nature of the active pharmaceutical ingredient. The crystals may be used as such, and in one aspect of the present  
10          invention the crystals consist essentially of simply the crystal lattice component and the API. Alternatively, the crystals include the crystal lattice component and the API in combination with other pharmaceutically-acceptable adjuvants also contained within the crystals.

          The crystals of the present invention are preferably formulated as  
15          pharmaceutical materials for ultimate delivery in solid or liquid form. In such applications, the crystals are typically formulated with common, compatible, pharmaceutically-acceptable adjuvants, such as excipients, diluents, carriers or mixtures thereof. For purposes herein, the term "pharmaceutically-acceptable" refers in this context to the excipients, diluents or carriers, as well as coatings or  
20          other components referred to elsewhere, being compatible with the other ingredients of the formulation and not deleterious to the recipient thereof.

          Examples of excipients, diluents, and carriers that are suitable for such dosage forms are well known in the art, and include the following: suspension additives such as tonicity modifiers, buffers, precipitants, and preservatives; fillers  
25          and extenders such as starch, lactose, dextrose, sucrose, sorbitol, mannitol, and silicic derivatives; binding agents such as carboxymethyl cellulose and other cellulose derivatives, alginates, gelatin, and polyvinyl pyrrolidone; moisturizing agents such as glycerol; disintegrating agents such as calcium carbonate and sodium bicarbonate; agents for retarding dissolution such as paraffin; resorption  
30          accelerators such as quaternary ammonium compounds; surface active agents such as cetyl alcohol and glycerol monostearate; adsorptive carriers such as kaolin and bentonite; and lubricants such as talc, calcium and magnesium stearate, and solid

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polyethyl glycols. Additionally, the adjuvant may comprise crystals of the crystal lattice component that are prepared without the included API.

The crystals may be coated to achieve various effects. In one approach, the crystals are coated with the same crystal lattice component which forms the underlying crystal, but without the included API. This assures that the coating and the underlying crystal have compatibility. The coating is then applied at a thickness which provides the desired effect, such as further protection of the active pharmaceutical ingredient, bulking of the crystal for handling, and/or effecting a sustained or delayed release of the active pharmaceutical ingredient. Alternatively, the same effects can be accomplished by coating the crystals with other compatible coating compositions, such as those which are well known in the pharmaceutical coating art. The crystals can also be coated so as to release the active pharmaceutical ingredient only or preferably in a particular part of the intestinal tract or other route of administration, possibly over a period of time. This is accomplished, in known fashion, using coatings, envelopes, and protective matrices made, for example, from polymeric substances or waxes.

It is a feature of one aspect of the present invention that the crystals and included API's may be packaged and administered to patients in discrete pharmaceutical dosage forms. The crystals may be used as such in solid form, or may be formulated into liquid solutions or suspensions prior to use. The compositions may accordingly be administered by various routes, for example, by the oral, rectal, vaginal, ocular, buccal, nasal, pulmonary, iontophoretic, topical or parenteral routes. Such compositions form part of the present invention and are prepared in manners well known in the pharmaceutical art.

The API's of the present invention are effective over a varied dosage range. Such dosages are readily accommodated by the present invention by permitting various sizes of crystals, concentrations of API, etc. It will be understood that the amount administered will be determined in light of the relevant circumstances, including the condition to be treated, the choice of API to be administered, the size of the patient being treated, and the chosen route of administration. Therefore, specific dosage ranges will differ accordingly, and are not limiting of the scope of the invention in any way.

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The compositions are formulated in one embodiment as a unit dosage form. The term "unit dosage form" refers to physically discrete units, such as tablets, capsules, and suspensions in vials or cartridge/pen systems suitable as unitary dosages, particularly as unitary daily dosages. Each discrete unit contains a predetermined quantity of active pharmaceutical material calculated to produce the desired effect, e.g., a prophylactic or therapeutic effect. The amount of active pharmaceutical ingredient contained in a given dosage unit can be varied depending on the manner of delivering the crystals. For example, a single dosage unit in tablet form may contain 1/4, 1/3, 1/2 or 1 times the unit dose for the active pharmaceutical ingredient, according to which 1 to 4 tablets would be administered to achieve a unit dose of the active pharmaceutical ingredient.

Therefore, in one aspect of the present invention, there is provided a pharmaceutical product in dosage form comprising a pharmaceutical delivery unit including a dosage amount of active pharmaceutical ingredient. The API is contained within the crystal lattice component, and a sufficient amount of crystals is included within the delivery unit to constitute the dosage amount of the API. It will be appreciated that the dosage amount of pharmaceutical may be obtained by provision of one or more crystals of the present invention. One form of the product consists essentially of a dosage amount of the crystals. In an alternative form, the pharmaceutical product consists of the dosage amount of the crystals.

The ultimate delivery forms may include, for example, tablets, soft and hard gelatin capsules, pellets, granules, marumes, lozenges, sachets, cachets, elixirs, suspensions, ointments, suppositories, injection solutions and suspensions, nonpareils, spheres and sterile packaged powders. The crystals may be coated or uncoated, and may be combined with various pharmaceutical adjuvants, including excipients, diluents and carriers, as already described. One preferred form of the pharmaceutical product consists essentially of the crystals, and an alternate form consists of the crystals and the pharmaceutically-acceptable adjuvants. The delivery forms are prepared by conventional techniques such as disclosed in Remington's Pharmaceutical Sciences, 19th Edition, Mack Publishing Company, Easton, PA (1995), which is incorporated herein by reference, or other treatises available to the skilled artisan.

Compressed tablets, for example, are prepared by well-known means which are conventional in the art. The tablets may be prepared by wet or dry granulation methods or by direct compression, and may be produced by any of a wide variety of tableting machines. Tablet formulations usually incorporate diluents, binders, lubricants and disintegrators, as well as the crystals with included API's. Typical diluents include, for example, various types of starch, lactose, mannitol, kaolin, calcium phosphate or sulfate, inorganic salts such as sodium chloride, and powdered sugar. Powdered cellulose derivatives are also useful. Typical tablet binders are substances such as starch, gelatin, and sugars such as lactose, fructose, glucose and the like. Natural and synthetic gums are also convenient, including acacia, alginates, methylcellulose, polyvinylpyrrolidone and the like. Polyethylene glycol, ethylcellulose and waxes can also serve as binders.

Certain solid pharmaceutical dosage forms of the present invention, most notably tablets, may be coated in conventional fashion with a wide variety of materials utilizing various processes. Typically, the products of the present invention may be sugar coated or film coated in accordance with well-known techniques. The coatings serve an aesthetic purpose as well as a practical one. Coatings can mask an unpleasant taste or odor, can increase ease of ingestion by the patient, and can serve to improve the ultimate appearance of the dosage form. Similarly, coatings can protect the product from the effects of air, moisture and light, can improve product identification, and can facilitate handling in packaging and fill lines during manufacture.

Various adjuvants may be included in the coating formulations as is well known in the art. These include, for example, permeability enhancers, plasticizers, antitacking agents and the like. A discussion of coating techniques and adjuvants is presented in United States Patent No. 5,015,480, issued to Childers et al. on May 14, 1991, the pertinent portions of which are hereby incorporated herein by reference. Further information pertinent to coating processes and equipment may be obtained from Remington's Pharmaceutical Sciences, supra.

Tablets are often coated with sugar as a flavorant and sealant, or with film-forming protecting agents to modify the dissolution properties of the tablet. The compounds may also be formulated as chewable tablets by using large amounts of

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pleasant-tasting substances such as mannitol in the formulation, as is now well-established practice. Instantly dissolving tablet-like formulations are also now frequently used to assure that the subject consumes the dosage form, and to avoid the difficulty in swallowing solid objects that bothers some subjects.

5           A lubricant is used in a tablet formulation to prevent the tablet and punches from sticking in the die of the tableting machine. The lubricant is chosen from such slippery solids as talc, magnesium and calcium stearate, stearic acid and hydrogenated vegetable oils.

10           Tablet disintegrators are substances which swell when wetted to break up the tablet and release the crystals. They include starches, clays, celluloses, algins and gums. More particularly, corn and potato starches, methylcellulose, agar, bentonite, wood cellulose, powdered natural sponge, cation-exchange resins, alginic acid, guar gum, citrus pulp and carboxymethylcellulose, for example, may be used, as well as sodium lauryl sulfate.

15           Enteric formulations are used to protect crystals and the included API's from the strongly acidic contents of the stomach. Such formulations are created by coating a solid dosage form with a film of a polymer which is insoluble in acidic environments, and soluble in basic environments. Exemplary films are cellulose acetate phthalate, polyvinyl acetate phthalate, hydroxypropyl methylcellulose  
20 phthalate and hydroxypropyl methylcellulose acetate succinate.

          The crystals with included API's may similarly be formulated into capsules for administration. Such capsules are prepared utilizing conventional encapsulating methods. A general method of manufacture involves preparing the crystals for use in capsules, such as by milling the crystals to a suitable size. The  
25 crystals are blended with desired excipients, diluents or carriers, and the resulting mixture is filled into suitably-sized capsules, typically hard gelatin capsules, using conventional capsule-filling machines. The usual diluents include inert powdered substances such as starch of many different kinds, powdered cellulose, especially crystalline and microcrystalline cellulose, sugars such as fructose, mannitol and  
30 sucrose, grain flours and similar edible powders.

          When it is desired to administer the crystal formulations as a suppository, the usual bases may be used. Cocoa butter is a traditional suppository base, which

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may be modified by addition of waxes to raise its melting point slightly. Water-miscible suppository bases comprising, particularly, polyethylene glycols of various molecular weights are also in wide use.

The crystals can also be similarly formulated as elixirs or suspensions for convenient oral administration or for parenteral administration, for instance by intramuscular, subcutaneous or intravenous routes.

The inventive crystals enable the design of sustained-release formulations based upon various factors to yield both the desired amount of active pharmaceutical ingredient and the desired pharmacokinetic profile for delivery of the active pharmaceutical ingredient. Selectively incorporating the active pharmaceutical ingredient into the crystal lattice, e.g., into a specific crystal growth sector, modulates the release profiles and can therefore be used to effect desired pharmacological properties. The choice of the crystal component and the process used to grow the crystals of excipient host and guest active pharmaceutical ingredient can be selected and/or modified to adjust parameters such as the delivery rate of the active pharmaceutical ingredient upon use of the formulation. The active pharmaceutical ingredient is incorporated into the crystal matrix at a selected rate, typically as only a small weight percentage of the overall crystal. This permits moderate and uniform rates of release.

Various approaches may be used to accomplish a delayed or sustained release of active pharmaceutical ingredient from the crystals. In a typical application the crystals of the desired size are combined with a compatible preservative and the mixture is injected subcutaneously or surgically implanted to provide a prolonged payout as the crystals dissolve as a result of contact with the surrounding body tissue and fluid. In one approach, the concentration of the active pharmaceutical ingredient in the crystals is reduced in order to effect a sustained release over time. Alternatively, larger crystals may be used to provide for more prolonged payout of the active pharmaceutical ingredient. In another approach, coatings on the crystals are used to affect the rate of release of the active pharmaceutical ingredient. Such coatings may comprise the same crystal lattice component but without the included active pharmaceutical ingredient, as well as other coating compositions useful for this purpose.

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In the alternative, the crystals of the present invention can be used to isolate and/or store the active pharmaceutical ingredient for later reconstitution into solution. The crystals may be stored for extended periods of time prior to reconstitution in view of the added stability accorded the API's by the encompassing crystal lattice component. The crystals are then combined with pharmaceutically-acceptable excipients, diluents or carriers to prepare the solutions for subsequent administration. The crystals are readily dissolved or suspended in appropriate diluents, which may be selected, for example, from the list previously provided with regard to diluents used to initially prepare the crystals.

Such solutions of dissolved crystals provide the active pharmaceutical ingredient free of the previously encompassing crystal lattice component. The solutions are useful, for example, for oral administration, parenteral use, or as suppositories. For parenteral administration, for example, the crystals may be formulated in a pharmaceutically-acceptable diluent such as physiological saline (0.9%), 5% dextrose, Ringer's solution, and the like, along with other additives to reduce the solubility of the crystals in suspension.

The resulting pharmaceutical formulations provide an active pharmaceutical ingredient which is included within the host crystal and has enhanced stability and shelf-life. The present invention therefore satisfies the desire to provide certain pharmaceuticals having an acceptable, room-temperature shelf-life. Depending on the circumstances, particularly the API involved, the desired shelf-life can be as little as one month, or may be at least one year, two years or more. The pharmaceutical molecules are generally isolated from one another and from the environment by the surrounding crystal lattice. The containment of the API in the solid crystal lattice also fixes the conformational orientation. This eliminates most of the potential degradation mechanisms, such as polymerization, oxidation, deamidation and proteolysis, that could otherwise reduce the stability of the pharmaceutical.

Methods demonstrating stability include but are not limited to high-performance liquid chromatography for purity and potency, FT-IR for secondary structure, in-vitro and in-vivo bioassays, and pharmacokinetic profiles.

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The crystals of the present invention are readily prepared and are useful in containing the included API in an isolated, oriented position within the lattice. The utility of the present invention is demonstrated in the following examples, which are illustrative in nature, and are not to be considered limiting of the scope of the present invention.

#### Example 1

To demonstrate the potential kinetic stabilization of proteins, green fluorescent protein (GFP) was incorporated into deionized  $\alpha$ -lactose monohydrate. GFP was selected because it is known to fluoresce only in its native conformation. Upon denaturation, the interior of the  $\beta$ -barrel of the molecule is exposed and the fluorescence of the p-hydroxybenzylideneimidazolinone chromophore is rapidly quenched. Typical crystal growth conditions involved the addition of 8 volumes of an approximately 1 mg/mL (approximately 37  $\mu$ mole) solution of GFP in 10 mM tris-HCl, pH8 and 10 mM EDTA to 100 volumes of a supersaturated aqueous solution (approximately 1.15 M) of deionized  $\alpha$ -lactose monohydrate. The mixed solution was allowed to stand for 3-4 days at room temperature in a 24-well plate. Crystals were harvested between 1-3 days and displayed a hatchet morphology as shown in Figure 1 with a broad base (010) further bounded by {100}, {110}, {1-10}, and {0-11}. Small (0-10) and {1-50} faces are also occasionally present. When illuminated with a long wavelength UV lamp, the crystals exhibited a bright green fluorescence localized within a sharply defined pyramid corresponding to the (010) growth sector. This indicates that GFP is selectively recognized and overgrown by the (010) face in preference to the others. More importantly, it is evidence that the GFP is in its native conformation. The level of GFP to lactose is approximately 0.008% (w/w).

GFP fluorescence intensity was measured as a function of time and temperature in three environments: saturated aqueous  $\alpha$ -lactose solution, lyophilized  $\alpha$ -lactose, and crystalline  $\alpha$ -lactose monohydrate. As shown in Figure 2, both the solution and lyophilized preparations lost nearly half of the fluorescence intensity at 333°K within one hour. The crystal showed no change at 333°K or even 343°K.

## Example 2

- To investigate the potential for incorporation of a biopharmaceutical into crystals of biocompatible excipients, studies were conducted using rhodamine-labeled glandular glucagon and lactose. As in the previous studies, the rhodamine label was used to facilitate the visualization of glucagon in the host crystals. Typical crystal growth conditions involved the addition of 5 volumes of a supersaturated solution of deionized  $\alpha$ -lactose monohydrate to 1 volume of an approximately 1.5 mg/mL (approximately 300 to 400  $\mu$ mole) of rhodamine-labeled glucagon in purified water. The mixed solution was allowed to stand at room temperature in a 24-well plate. Crystals were harvested between 1-3 days and displayed a hatchet morphology with a broad base. With the rhodamine label, glucagon inclusion was visible in the crystals as a well-defined pyramid corresponding to the (010) growth sector. The level of inclusion was determined to be approximately 0.1% (w/w).
- In-vitro dissolution experiments were performed on the glucagon/lactose crystals to evaluate potential for in-vivo, sustained-release pharmacokinetics. The release of rhodamine-labeled glucagon into solution was followed by fluorescence spectroscopy. In a typical experiment, 1-2 crystals were added to 100 microliters of phosphate buffered saline solution at room temperature and the increase in fluorescence of the solution was monitored over time. The release of glucagon from the dissolving crystals was generally complete after 24-48 hours depending on crystal size and was linear until the last few hours of dissolution. Additional details are contained in the article entitled "Stabilization of Proteins in Single Crystal Hosts: Green Fluorescent Protein and  $\alpha$ -Lactose Monohydrate," M. Kurimoto, P. Subramony, R. Gurney, S. Lovell, J.A. Chmielewski, B. Kahr, J. Am. Chem. Soc. 1999, 121, 6952-6953, which article is hereby incorporated herein by reference.

## Example 3

- To demonstrate the universality of this technology for incorporation of a diversity of biopharmaceuticals into crystals of biocompatible excipients, studies were conducted using biosynthetic human insulin and insulin analogs,

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V8-GLP-1(7-37)OH, a glucagon-like insulintropic peptide-1 analog, exendin, and human growth hormone in deionized  $\alpha$ -lactose monohydrate or phthalic acid. Information regarding V8-GLP is available in United States Patent No. 5,705,483, issued to Galloway and Hoffman on January 6, 1998, which patent is hereby  
5 incorporated herein in its entirety. For information regarding exendin, see, e.g., R. Goke, H.C. Fehmann, T. Linn, H. Schmidt, M. Krause, J. Eng, B. Goke, "Exendin-4 is a High Potency Agonist and Truncated Exendin-(9-39)-amide an Antagonist at the Glucagon-like Peptide 1-(7-36)-amide Receptor of Insulin-secreting Beta-cells," J. Biol. Chem. 1993, Sep 15, 268(26), pp. 19650-5, which reference is  
10 hereby incorporated herein in its entirety.

Typical crystal growth conditions involved the addition of 1 volume of an approximately 10 mg/mL rhodamine- or Texas red-labeled peptide or protein in 0.1M phosphate-buffered saline solution (PBS, pH7.4) to 10 volumes of a supersaturated  $\alpha$ -lactose solution or phthalic acid solution. Supersaturated  
15 solutions of purified  $\alpha$ -lactose were obtained by adding 0.41 grams of  $\alpha$ -lactose to 1 mL of purified water, allowing to dissolve in a 50-70°C water bath, and cooling to room temperature. Supersaturated solutions of phthalic acid were prepared by adding 0.05 grams of phthalic acid to 1 mL of either 70/30 (v/v) water/acetonitrile or 90/10 water/ethanol, allowing to dissolve in a 50-70°C water bath, and cooling  
20 to room temperature. Larger volumes of supersaturated solutions are obtained by using the same solute-to-solvent ratio.

The solutions of labeled peptide or protein with the supersaturated  $\alpha$ -lactose or phthalic acid were mixed by swirling, transferred to a 24-well crystallization plate or other suitable glass or polypropylene container, and allowed  
25 to stand at room temperature. Crystals were harvested in 4-5 days and rinsed with hexanes, ethanol, or methanol. All preparations yielded crystals with dye-labeled protein inclusions as determined by microscopic examination using an Olympus SZ-40 microscope with a CCD vision camera.

The shape of the crystals formed was dependent on the solvent system used  
30 for the phthalic acid. The crystals formed with phthalic acid in water/ethanol were long, petal-shaped clusters. The crystals formed with water/ethanol were smaller

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and rhombic. Crystals of labeled-insulin/lactose were dissolved in PBS and analyzed by HPLC. The level of insulin inclusion was determined to be approximately 0.1%. This process is scalable from 100  $\mu$ L to several liters. The larger volume crystallizations were performed using glass beakers, or other appropriate large containers, covered with watch glasses.

Using the same process, unlabeled insulin and exendin have also been incorporated into  $\alpha$ -lactose monohydrate and phthalic acid crystals. Upon dissolution of the crystals with 0.01N HCl, purified water and/or methanol, the level of peptide included in these hosts was determined by analysis of the sample solutions with an HPLC system in the flow-injection analysis mode using a chemiluminescent nitrogen-specific detector (CLND). The level of peptide inclusions ranged from approximately 0.1% to 10% (w/w). These data demonstrate that the level of inclusion can be manipulated by appropriate choice of guest and host molecules in addition to crystallization conditions. See also the following references which are hereby incorporated herein in their entirety: M. Windholz, (editor). Merck Index, 10<sup>th</sup> edition, p. 769; R.A. Visser, Neth. Milk Dairy Journal, 34, 1980, pp. 255-275; J. Chmielewski, et al., JACS, 119, 43, pp. 105665-10566.

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